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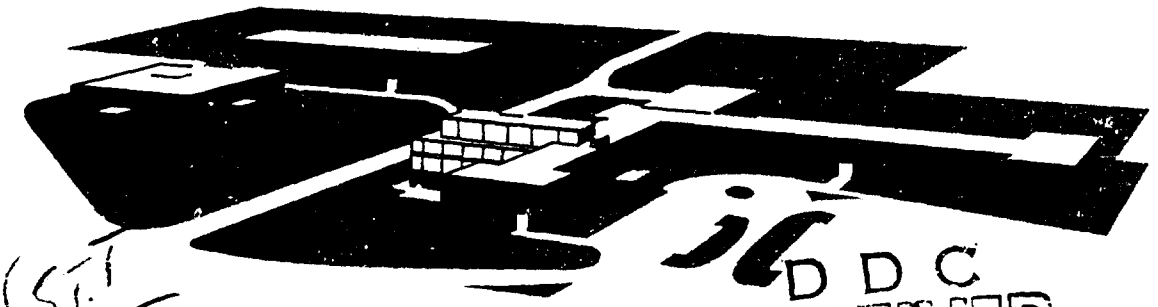
FINAL REPORT

SOCIAL INSTITUTIONS AND THERMONUCLEAR WAR -- A CASE STUDY OF HIGHER EDUCATION



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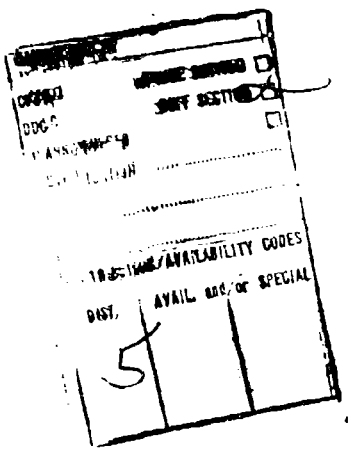

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SUMMARY OF SOCIAL INSTITUTIONS AND THERMONUCLEAR WAR -- A CASE STUDY OF HIGHER EDUCATION

Contract OCD-PS-66-18

Work Unit 3521A

January 1967

Copy No. 1 of 160 Copies

Prepared by:

Robert B. Kiker, Jr.
Anna M. Kiker

SOCIAL INSTITUTIONS AND THERMONUCLEAR WAR -- A CASE STUDY OF HIGHER EDUCATION SUMMARY AND GENERAL CONCLUSIONS

The research presented in this report deals with the problem of insuring the effective operation of higher education as a social institution in the post-attack society. The report takes the position that social institutions in general and higher education in particular will play an important role in rebuilding the social organization and preventing cultural stagnation after thermonuclear war. Higher education will be responsible for replenishing the human resources necessary for technological growth following disruption, and its ability to perform this function will depend to a large extent upon the steps that are taken both pre- and post-attack to minimize system disruption and hasten recovery.

Phase I of the research constituted an initial investigation of the present higher education system's physical and operating characteristics to determine their susceptibility for disruption. The results of that phase indicated that the system is characterized by a number of physical properties which render it highly vulnerable to disruption from attack. First, most of the nation's higher education capability is concentrated on the east and west coastlines and in the immediate vicinity of large metropolitan centers. Thus, many schools are likely to be damaged by the peripheral effects of bombs directed toward population centers and other targets of a strategic nature within these areas. Second, specific states and geographic sectors produce disproportionate quantities of college graduates trained in particular professions. These trained individuals are supplied to the nation as a whole, and dependencies exist between the geographic areas where the individuals are employed and the areas where they are trained. Nuclear destruction in these centers of education will thus create future skill deficits for the entire nation. A third type of vulnerability occurs with respect to the nation's largest universities. These schools are few in number, but produce many graduates. Not only do they produce vast numbers of students, but they make large contributions in research and consultation to society. They have the most advanced facilities and equipment, the highest trained faculty, the broadest range of curricula. Because of these research and leadership contributions they may constitute strategic targets in and of themselves. This is further accentuated by the fact that they are located primarily in large metropolitan areas and are thus quite likely to receive heavy damage or complete destruction even if they are not targets themselves.

The results of Phase I also called attention to what may be considered elasticity within the higher education system. A high degree of elasticity is present in the form of small and intermediate size colleges. These schools exist in large numbers and are distributed relatively evenly throughout the nation. They are characterized by aspects such as high faculty to student ratios, many library volumes per student, little dependency upon government funding, and high physical plant value per student which indicate their potential for expansion. If properly directed, they will provide a cushion effect should heavy destruction occur in the large universities.

Phase II of the reported effort was designed to expand and complement these findings by (1) verifying the existence of the system vulnerabilities, and (2) clarifying the nature of system elasticity to permit its control and manipulation through countermeasures. The verification process was performed by applying a hypothetical attack pattern to the nationwide higher education system and assessing the resulting damage across geographic sectors, different types of schools, and specific curricula. Elasticity was studied by analyzing the specific damage incurred by a small sample of colleges and universities to determine ways in which the capability they provided could be reinstated. Based upon the results of that analysis, a series of countermeasures were specified to expedite the reinstatement of education capability through protection and the exploitation of elasticity.

The Five City Study provided a convenient framework for conducting Phase II of the higher education study. The first attack pattern specified for the Five City Study was utilized in the nationwide damage assessment. The results of that assessment verified the assertions of Phase I and provided data for use in the study of elasticity. The sample colleges and universities used in the elasticity analysis were those existing in the five cities of Albuquerque, Detroit, New Orleans, Providence, and San Jose. Damage to the schools in these cities was assessed from the standpoint of both the physical facilities and personnel (faculty and administration.)

The results of the elasticity analysis indicated that physical facility losses will considerably exceed those within faculty and administrative personnel. This will, of course, be a virtue, since it is easier to construct buildings than to train faculty. Some degree of caution is necessary, however, with respect to assuming that post-attack education capability will thus be increased. Faculty

members may be needed for work and consultation in their respective fields during immediate recovery, and thus will not be available for teaching. This is especially likely to be true in the case of medical instructors, engineers, economists, and agriculture instructors.

Small colleges will offer a number of advantages for reinstating capability. They will be able to provide physical facilities and may be combined to form capable departments in many fields including graduate study. Their capability may be increased by adopting techniques of mass instruction (television) normally used in large universities. A disadvantage was noted, however, with respect to relying upon small colleges exclusively. The results of the elasticity analysis indicate that undamaged intermediate size schools provide greater capability in several curricula. Especially heavy losses are likely to occur with respect to curricula such as medicine, engineering, and law. Losses in these fields will apply to both faculty and physical facilities due to their present relationship to large cities and other targets. Small colleges are not presently geared to adopt these curricula and thus do not offer elasticity in this respect. Intermediate schools frequently have departments in these fields and thus provide greater immediate capability for expansion.

Conclusions with respect to countermeasures hinge basically around the promotion of changes within the present higher education system, and the allocation of government funds and other forms of assistance with respect to the post-attack system. Steps should be taken in the pre-attack society to reduce the vulnerability of the nation's large schools through decentralization and the avoidance of cities and strategic targets. Small colleges should be notified of the role they may be expected to play in the post-attack system, and steps should be taken to prepare them for assuming that role. Graduate schools should be instated and greater emphasis placed upon technical and scientific curricula. Plans for the allocation of government funding should be prepared in the pre-attack system and placed in effect as soon as possible post-attack. The plans should place emphasis upon the expansion of small and intermediate schools and avoid wasting money and effort on the rebuilding of seriously damaged large universities. The most efficient procedure will be to make the intermediate schools of today into the large universities of tomorrow.

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(10) Robert B. King, Jr.
Anna M. Kleiner

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ABSTRACT

This report presents an investigation into the post-attack capability of the institution of higher education. The existing higher education system was described in terms of physical and organizational characteristics which render it vulnerable to disruption from nuclear attack. The vulnerabilities were verified by assessing system damage resulting from a hypothetical attack. Operational elasticity inherent in the system was clarified with respect to the post-attack capability of a sample of schools, and countermeasures designed to protect the system and hasten its recovery were developed.

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TABLE OF CONTENTS

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LIST OF ILLUSTRATIONS

Reverse (Page viii) Blank

LIST OF TABLES

LIST OF TABLES (Cont'd)

CHAPTER I. INTRODUCTION

This report has been prepared for the Office of Civil Defense as a contribution to the overall knowledge of that agency regarding the societal consequences of thermonuclear war. It is based upon research conducted by HRB-Singer, Inc., under Contract OCD-PS-66-18, and deals with the problem of insuring the effective operation of organized social institutions following a nuclear attack on the United States. The institution of higher education is presented as a specific case in point.

The research was prompted by a previous effort by HRB-Singer, Inc.[1] in which a procedure was developed for analyzing the operating structure of organized institutions. An initial analysis, based upon that procedure and performed on the institution of higher education indicated that (1) certain aspects of the higher education system render it highly vulnerable to damage and disruption as a result of nuclear attack and (2) the operating system has a high degree of elasticity inherent in its structure which could be exploited to hasten recovery following disruption.

The study reported here was designed to expand and complement these earlier findings by (1) verifying the existence of system vulnerabilities and (2) clarifying the nature of system elasticity to permit its control and manipulation through countermeasures. The verification process was performed by applying a hypothetical attack pattern[2] to the nationwide higher education system and assessing the resulting damage across geographic sectors, different types of schools, and specific curricula. Elasticity was studied by analyzing the specific

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[1] The previous effort was performed under Contract OCD-PS-65-48 and reported in "Higher Education and the Post-Attack Period", King, R. B. ; Kleiner, A. M. ; and Hambacher, W. O., August 1965.

[2] The attack pattern utilized was originally generated by the Office of Civil Defense for use in their Five City Study. It is referenced in the volume--Five City Study, Guide for Participants, May 1965, Systems Evaluation Division, Research Directorate, Office of Civil Defense.

damage incurred by a small sample of colleges and universities[1] to determine ways in which their capability could be reinstated. The results of this analysis are a series of countermeasures designed to exploit elasticity and rapidly reinstate education capability.

In view of the inextricable ties between the first study and the study reported here it has been necessary, for the sake of clarity, to include many of the results from the previous study throughout this report. Summarization has been employed wherever possible and redundancy hopefully has been kept to a minimum. In order to avoid confusion when results from both studies are presented together, the initial study has been designated Phase I, and the study under report herein is called Phase II. There is some additional merit in these designations since both studies together constitute OCD Work Unit 3521A.

The report is organized into seven chapters. Chapter 2, entitled "Background and Rationale," presents further introductory material intended to establish the specific premises upon which both studies must rest. That chapter defines what is meant by organized social institutions and attempts to answer the question of why civil defense planners should concern themselves with such institutions and specifically with the institution of higher education. It establishes the rationale for viewing higher education as a system and summarizes the basic approach underlying both study phases.

Chapter 3 provides a review of the findings from Phase I which served as the groundwork for Phase II. Chapter 4 presents the procedures and results of the nationwide damage assessment. Comparisons are made with the predictions of the Phase I study and the implications of both sets of findings are discussed. Chapter 5 is devoted to the explication of elasticity. Colleges and universities in the five cities are examined in detail and a post-attack capability profile is constructed for each city. Chapter 6 combines the results of both study phases for the purpose of specifying countermeasures which may be taken both pre- and post-attack to insure the preservation of a viable higher education system. Potential ways of increasing educational capability are outlined and discussed. Conclusions and a summary constitute Chapter 7.

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[1] The colleges and universities comprising the sample were those existing in the cities of Albuquerque, Detroit, New Orleans, Providence, and San Jose. These cities were selected for analysis in the Five City Study.

CHAPTER II. BACKGROUND AND RATIONALE

A. SOCIAL INSTITUTIONS AND THE POST-ATTACK SOCIETY

The advent of a thermonuclear conflict involving the continental United States does not presuppose total or wholesale physical destruction. Many writers would agree that ". . . destruction will be confined to a small percentage of the geographical area of the United States" and ". . . in large areas of the geographic United States people would emerge to a local world that was physically intact and socially very largely intact".[1] Even if the above statements represent a somewhat optimistic picture of the post-attack circumstances, the probability of such circumstances is significantly higher than that of total destruction. A middle position is represented by Stonier[2] who graphically describes the medical, food, housing, and water problems existing post-attack as well as the social and economic consequences and the dangers of epidemics and social disorganization. Although this well-documented account of post-attack conditions at first engenders a reaction of shock and fear, careful reading and thought lead to the conclusion that proper preparation can clearly and significantly mitigate the effects of thermonuclear attack. One of the, if not the most potent mitigating factor, is the prevention or reduction of social disorganization. In discussing Mesopotamia, a country in which seven centuries later the population was only one third that which it was before a devastating war, Stonier states, "A demoralized country neither rebuilds nor recovers rapidly. Instead, social institutions disappear,, individual skills are lost, knowledge recedes, and the pall of a dark age descends gloomily on an increasingly ignorant and suspicious people unable to cope with a hostile environment. Such an environment would be created by a nuclear disaster." (p. 167.) Under the circumstances of post-attack, the necessity and desirability of protection and guaranteeing the continued operation of society's complex institutions, such as higher education, medical installations, mental hospitals, financial and insurance complexes, law enforcement, etc., become paramount.

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[1] NAS-NRC Committee on Behavioral Research (Advisory to OEP) Emergency Planning and Behavioral Research, Washington, D. C., 1962.

[2] Stonier, Tom. Nuclear Disaster, Meridian Books, The World Publishing Co., N. Y., 1964.

It would be extremely difficult, if not impossible, to study all of our society's complex institutions in this regard, but a beginning should be made. Careful consideration of the problem leads to the conclusion that higher education provides a feasible and valuable starting point. This conclusion is based upon (1) the relevance of higher education in the post-attack society and (2) the researchability of this institution. These rationale are explained in the following two subsections.

B. HIGHER EDUCATION AND THE POST-ATTACK SOCIETY

Higher education is closely interrelated with most aspects of American life and American institutions. It contributes significantly to the cultural and economic life of the country and supplies trained personnel to business, industry, the professions, and the arts. Additionally, its research products in a wide variety of fields (agriculture, mining, human behavior, space technology, etc.) significantly influence the immediate and long-range lives of individuals, groups and other social institutions and processes. These trained personnel and research products constitute an important segment of the nations resources.

Nordlie and Popper[1] state that "the level of a society's economic development manifests itself and can be measured in terms of productivity. A nationwide nuclear attack would sharply reduce productivity immediately and perhaps completely stop producing activities for some period of time. In a broad sense, recovery has to do with resumption of producing activities and the achievement of levels and kinds of productivity which would meet the demands of the surviving population."

Human resources are essential for productivity. After a nuclear attack, productivity will be greatly affected by the availability and distribution of the nation's resources. Many of the needs for production and human resources will be immediate. Rebuilding, repair and production of certain key commodities must begin immediately for the simple purpose of sustaining life. Meeting these immediate needs will primarily require the use of the available labor force skills. Problems involving the maintenance of life certainly will require primary attention.

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[1] Nordlie, Peter G. and Robert D. Popper, Social Phenomena in a Post Nuclear Attack Situation, Synopses of Likely Social Effects of the Physical Damage, 1961.

Skilled laborers will be required in the building trades, transportation, communication, food processing, etc. Far more complicated problems of productivity, however, will rapidly come into focus. These will involve the maintenance and restoration of the social system, and will require professional talents of a different magnitude and quality.

Even in a relatively peaceful pre-attack world, the social system requires constant training of new people to replenish the supply of educated human resources required for its operation. During a nuclear attack, casualties will undoubtedly occur among those individuals possessing needed skills, and these losses to the professional labor force will require replacement for the social system to recover. An additional problem may occur, however, due to the fact that the post-attack social system is likely to be characterized by disproportionate increases in requirements for specific skills and services. For example, high premiums are likely to be placed upon individuals trained in economic and social planning, medical services, sanitation, management, administration, and organization. The needs may be especially great for individuals skilled in planning and development. Post-attack rebuilding may require use of common materials in new ways and development of new materials. Architects and engineers will be required for efficient utilization of available materials and research leading to new materials.

These requirements for trained individuals will be manifested in the form of demands placed upon the institutions of higher education and other training facilities in the nation. The problem of meeting these demands will be further complicated by the fact that higher education itself will not emerge intact and unscathed from a nuclear attack. The very fact that higher education is an integral part of the social system testifies that it will suffer many of the same hardships imposed upon the social system as a whole. Just as the many segments of society depend on higher education for training of the nation's human resources, higher education is dependent upon society for the resources necessary for higher education. These required resources include trained individuals to serve as faculty and administrators, specialized buildings and equipment, financial support and services, and individuals capable of college level training--all of which are susceptible to the damaging and disorganizing effects of a nuclear attack, and all of which may be needed for other roles and services in the post-attack society. Special problems are likely to be experienced regarding faculty

and administrative personnel. Faculty members are also highly trained professional personnel whose skills will be needed for work apart from their normal positions in the higher education system. Immediate requirements for university staffing could be temporarily met by utilizing people with training in specific areas, but this practice may jeopardize educational quality over longer periods of time due to the fact that such people would not be skilled in teaching methods and institutional administration.

The importance of higher education in the current fabric of society is attested to by the past and current volume of research designed to describe, evaluate, and improve this complex institution. The forms of these studies, however, have been on the role of higher education in relatively peaceful circumstances. Although recent world events have changed the direction of study somewhat toward preparation for conflict, the outcome has been increased preparation for cold rather than hot war with no attention given to the capabilities of higher education in the post-attack period. The role of higher education in the present society and the probable composition of the post-attack world suggest that higher education will be called upon to play a significant role in both the immediate and long-range post-attack recovery of our society. It can, however, make a significant contribution to post-attack recovery only if circumstances are created pre-attack that will allow its potential to be realized.

C. THE RESEARCHABILITY OF HIGHER EDUCATION

Not everything which is referred to as a "social institution" is researchable, at least not researchable to the extent of producing results of some utility to civil defense planners. If the study of any social institution is to be feasible and produce results of value, that institution must be definable and have certain measurable components for inclusion in the study. For that reason, what may be termed "purposeful, organized institutions" are more appealing to the researcher who envisions utility in his results. Organized institutions exist as systems, which are characterized by interdependencies among their comprising units, and measurable, physical properties.

Like most organized, purposeful institutions, higher education exists as both a concept and a physical entity. The concept may not disappear as a result of destroying the physical properties. Destruction of the physical properties will, however, render the institution inoperative, and reduce its existence to

only a concept. It is meaningful, therefore, to study the physical properties of institutions like higher education to determine what their operating characteristics will be after disruption.

Organized institutions are thus potentially researchable because they have physical properties which are systematic and measurable, and because these physical properties are directly involved in the effective operation of the institution. Before researchability can be assured, however, two other aspects must be considered. First is the problem of the number and nature of the components which comprise the institution. If the number is too large, the probability of obtaining valid and usable results over a reasonable period of time is small. If the structure of each component is highly varied, the research will have no applicability beyond the particular components studied. It is here that higher education has a distinct advantage over other institutions in terms of researchability. The educational facilities which comprise higher education exist in a finite, manageable number (approximately 2,000) and all facilities are similar in terms of their operating structure (each school consists of a faculty, students, a library, and an administration staff, and specific housing units, for example.) The products of each facility (trained individuals and research) are not intended for any single locale, but contribute to the general society[1]. Thus certain realistic bounds can be drawn on the measurement process, and researchability is facilitated.

The problem of securing sufficient data within the bounds of typical research contracts also requires consideration. Short-term studies dealing with research topics as broad and complex as the post-attack status of social institution must rely heavily, if not exclusively, upon existing data sources. The availability of meaningful data is essential to the success of the study. Here again, higher education enjoys a distinct advantage over other similar institutions. Though often disorganized and widely scattered, actuarial data pertaining to higher

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[1] The reader who feels that these characteristics do not sound particularly manageable should compare this institution with that of law enforcement. There are as many police departments as there are communities across the nation. Although their operating structures are fairly similar, they differ widely from other law enforcement agencies such as state police, sheriff departments, the FBI, and various militia groups.

education in this country exists in abundance. The researcher is thus spared many of the frustrations and the expense of collecting original data, and his task becomes one of organizing the existing data into a structure or form which will permit the extraction of meaningful conclusions.

D. THE BASIC APPROACH

Although the specific techniques of analysis employed in Phase II differ from those of Phase I, both phases involve a common basic approach which deserves mention at this point.

Higher education can be compared to a manufacturing process having an inflow of raw materials and an outflow of finished products. The finished products can be assumed to be in compliance with a requirement on the part of society, and the raw materials are in turn supplied by society. In the case of higher education, the incoming raw materials are in the form of students, and the output or product consists primarily of trained individuals or degree holders.

Like many manufacturing complexes, the member facilities of higher education are distributed throughout the nation. They are not distributed uniformly, however. As will be shown in the next chapter, the member colleges and universities are densely clustered on the east and west coastlines and in the vicinity of large metropolitan areas.

Higher education is also quite similar to manufacturing in the sense of diversification of products. Separate facilities produce different products. To a great extent the size of an education facility determines the nature of its products. Small colleges tend to produce only people trained in teaching or in liberal arts, while large colleges and universities have a broad range of curricula. Indeed, certain curricula such as those pertaining to agriculture and many of the professions are found only in the very large facilities.

As in manufacturing, higher education facilities obtain a portion of their raw materials from locales other than the particular locale where the production occurs. Likewise, a large portion of the finished products are distributed in distant regions of the country. A type of stable system is thus established with a complex, but highly advantageous, exchange of resources.

The civil defense planner faced with the task of insuring effective operation of a manufacturing process, or the availability of a product in the post-attack society, would seek immediate answers to such questions as: How and to what extent is production likely to be impaired as a result of nuclear attack? Is it likely that production losses will be greater for certain product types than others? And, what can be done in the way of countermeasures to both protect against production losses and rapidly reinstate capability in the event that losses do occur. He would obtain answers through study and inspection of the operating characteristics of the production system and the presumed characteristics of a nuclear attack.

To the extent that higher education compares to a manufacturing process and trained individuals constitute a system product, these same questions are applicable. The basic approach thus involves examination of the present system's operating characteristics to determine how and to what extent it may be disrupted, and how capability may be preserved and/or reinstated.

The approach reflects the position that the very existence of today's higher education system--its size, its complexity, and its diversity--tells a great deal about its capabilities and the demands of society for its products, both in our present society and post-attack. Whether the present system is good or bad, adequte or inadequate, is not important. What is important is that it is a product and an integral part of a society which the American people would conceivably endeavor to return to as rapidly as possible in the event that it is damaged or disrupted by nuclear war.

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CHAPTER III. IMPORTANT SYSTEM CHARACTERISTICS

The layman, and frequently the professional educator has a tendency to think of higher education in terms of a concept rather than a physical system. When physical attributes are considered, they are usually done so with respect to a particular school and its operating structure. Civil defense planners, on the other hand, should think of higher education in terms of capability--brought about and existing through the combined efforts and operations of the many physical facilities throughout the nation. When viewed in that perspective, a number of the system's physical characteristics merit greater than normal attention. This chapter discusses two of these characteristics, the geographic distribution of schools, and the small school versus the large university. They merit attention because they carry important implications with respect to the system's post-attack capability.

A. THE GEOGRAPHIC DISTRIBUTION OF SCHOOLS

One of the most outstanding aspects of the present higher education system is the geographic distribution of its member institutions. Figures 1 through 3 illustrate this distribution quite vividly.[1]

As can be seen in the illustrations, extreme clustering is found in the northeast sector from Philadelphia to Boston and in the vicinities of Los Angeles and San Francisco. The distribution in the entire eastern half of the nation is dense but fairly evenly distributed. In the western half, broad expanses of the nation have no higher education facilities. Special note should be taken of the number of very large universities located in the vicinity of the large east and west coast cities.

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[1] Figures 1 through 3 are photographs of a map prepared in Study Phase I using colored pins to represent the location of all accredited colleges and universities in the nation. The different pin sizes and different colors represent different school size categories. The large black and large gray pins especially apparent in Figures 2 and 3 represent the very large schools, black indicating a total enrollment of 10,000 to 20,000 and gray 20,000 and above.

FIG. 1 TOTAL DISTRIBUTION OF ACCREDITED COLLEGES AND UNIVERSITIES

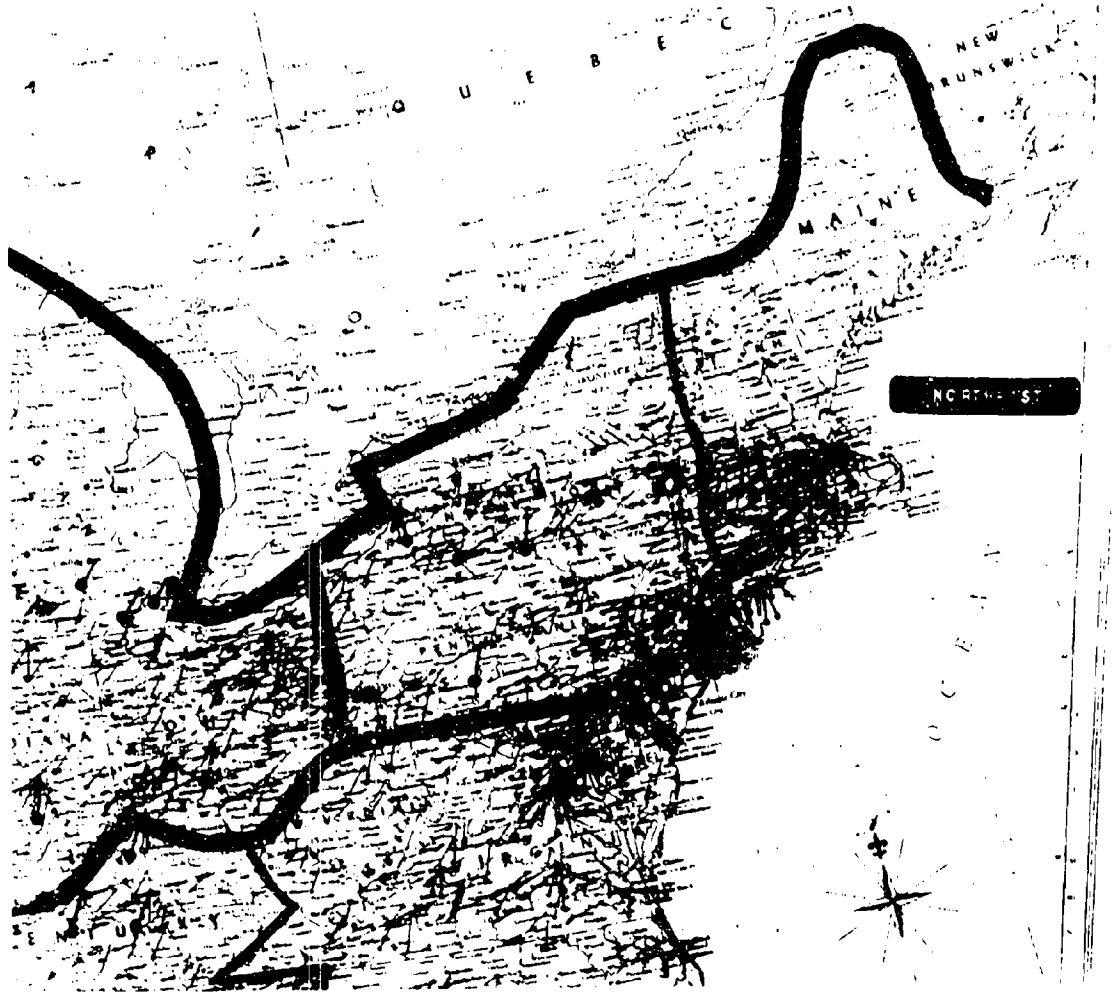

FIG. 2 DISTRIBUTION OF ACCREDITED COLLEGES AND UNIVERSITIES -- NORTHEAST STATES

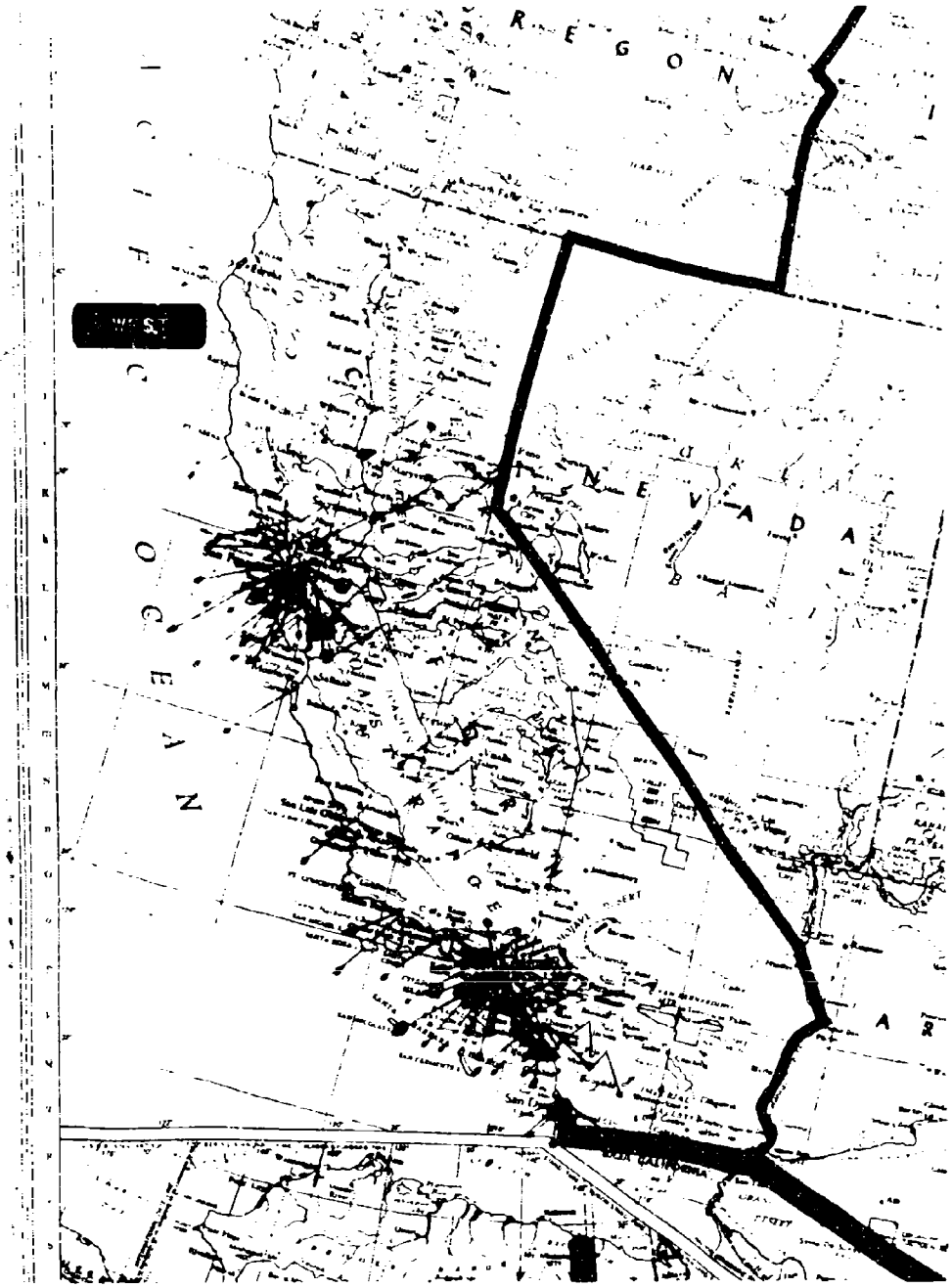

FIG. 3 DISTRIBUTION OF ACCREDITED COLLEGES AND UNIVERSITIES -- WESTERN STATES

Figure 4 and Table 1 show the relative distribution of student enrollment (all curricula combined) by states. The difference indicated in Figure 4 becomes even more extreme when the distribution within the states is considered. California, for example, not only has a high percentage of students, but approximately 95% of this enrollment is found in the cities of San Francisco and Los Angeles. The existence of a system vulnerability can be inferred from such a situation. A vulnerability exists due to the fact that such extreme clustering increases the probability that damage will occur to the system. Large cities such as New York, Boston, Philadelphia, San Francisco, and Los Angeles are almost universally viewed as likely targets in a nuclear attack against population.

An additional problem arises due to facility clustering when consideration is given to the production of individuals trained in specific professions. Specific states and geographic sectors produce disproportionate quantities of graduates trained in particular professions. These trained individuals are supplied to the nation as a whole, and dependencies exist between the geographic areas where they are employed and the areas where they are trained. A ready example is provided in the case of geologists.[1] The state of Texas employs approximately 28% of the nation's trained geologists--far more than any other state. The major portion of these geologists, however, are trained in the states of New York and California. Thus, if the post-attack need for geologists remains anywhere near its present level, there will be a distinct shortage of trained graduates should the production facilities in New York and California receive significant damage.

[1] Geology is one of twenty-seven professions examined in this respect during Study Phase I.

TABLE 1 DISTRIBUTION OF HIGHER EDUCATION STUDENTS ACCORDING TO STATE -- 1964

ALABAMA	37,408	MONTANA	14,610
ALASKA	1,159	NEBRASKA	35,897
ARIZONA	33,236	NEVADA	3,661
ARKANSAS	26,818	NEW HAMPSHIRE	11,682
CALIFORNIA	254,257	NEW JERSEY	94,130
COLORADO	43,849	NEW MEXICO	17,716
CONNECTICUT	54,591	NEW YORK	491,642
DELAWARE	5,366	NORTH CAROLINA	67,872
DIST. OF COLUMBIA	36,865	NORTH DAKOTA	13,008
FLORIDA	51,452	OHIO	179,443
GEORGIA	45,786	OKLAHOMA	54,623
HAWAII	10,796	OREGON	40,308
IDAHO	8,916	PENNSYLVANIA	207,780
ILLINOIS	163,042	RHODE ISLAND	16,411
INDIANA	101,865	SOUTH CAROLINA	26,031
IOWA	56,312	SOUTH DAKOTA	14,722
KANSAS	51,879	TENNESSEE	65,538
KENTUCKY	47,872	TEXAS	156,803
LOUISIANA	62,519	UTAH	36,138
MAINE	9,818	VERMONT	9,058
MARYLAND	49,310	VIRGINIA	47,769
MASSACHUSETTS	131,762	WASHINGTON	53,306
MICHIGAN	138,896	WEST VIRGINIA	30,847
MINNESOTA	73,805	WISCONSIN	80,284
MISSISSIPPI	26,313	WYOMING	4,828
MISSOURI	81,555	TOTAL	3,380,565

SOURCE: AMERICAN UNIVERSITIES AND COLLEGES, 1964.

B. THE PROBLEM OF LARGE UNIVERSITIES

A thermonuclear attack directed against the nation's cities and metropolitan centers could inflict heavy damage on the higher education system. If the attack is accurately directed, production in several professions may be severely impaired. The primary reason for such extreme vulnerability is geographic clustering. There are other factors involved, however. This subsection defines some of the contributing factors.

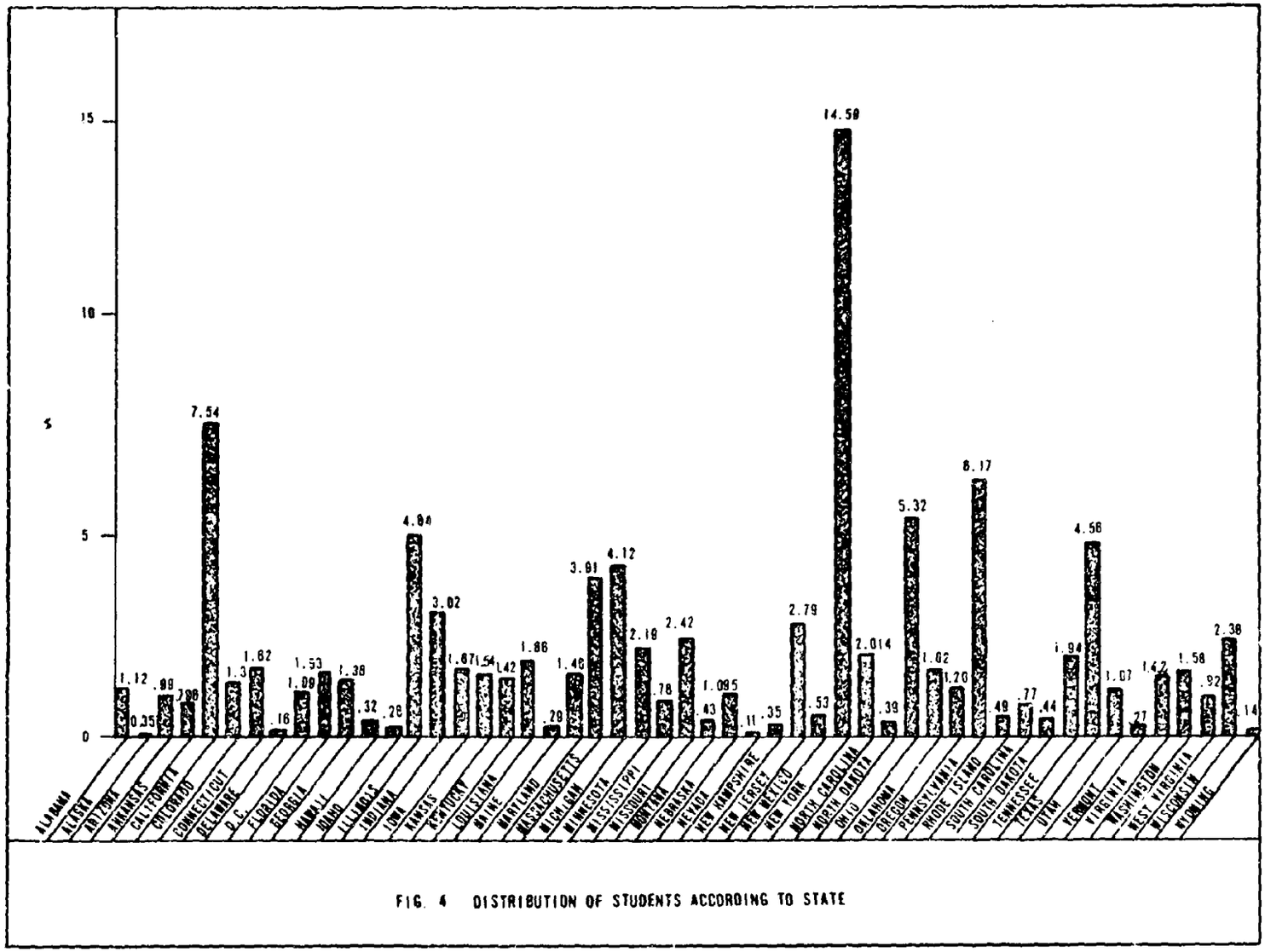

FIG. 4 DISTRIBUTION OF STUDENTS ACCORDING TO STATE

The large universities and "multiversities" of the nation are heavily concentrated in cities and metropolitan areas. Eighty-five percent of the nation's largest schools (enrollment of 20,000 and above) are located in cities over 100,000 population. Thirty-eight percent are located in cities with a population over 1,000,000. This is especially significant considering that there are only five cities of this size in the nation, and four of them are in the northeast quarter (New York, Chicago, Philadelphia, and Detroit.)

The loss of even a few of these high enrollment universities could severely damage the system due to the following factors:

1. Total Production

There are presently 1171 accredited institutions of higher education in the nation. Only 74 of these schools are what this study refers to as "large universities" (enrollment greater than 10,000.) These 74 schools process approximately 42 percent of the nation's higher education students.[1]

2. Curricula Structure

Large universities are characterized by widely diverse curricula. Curricula such as veterinary medicine, pharmacy, dentistry, architecture, and medicine are found predominately in large universities. These curricula would experience especially high losses in total capacity for production should large universities be heavily damaged.

3. Value of the Physical Plant

Figure 5 indicates that large universities have an extremely high physical plant value. This would be expected on the basis of size alone, i.e., buildings and laboratory equipment must exist in some proportion to the number of students enrolled. Consideration must be given, however, to the fact that large schools have more total money to spend on buildings and equipment and are therefore more likely to be able to keep up with scientific and technical advancements in facilities and equipment. With many items of equipment, once the initial expenditure is made, the equipment can be used by many students at very little additional expense. For example, a large university can afford to build

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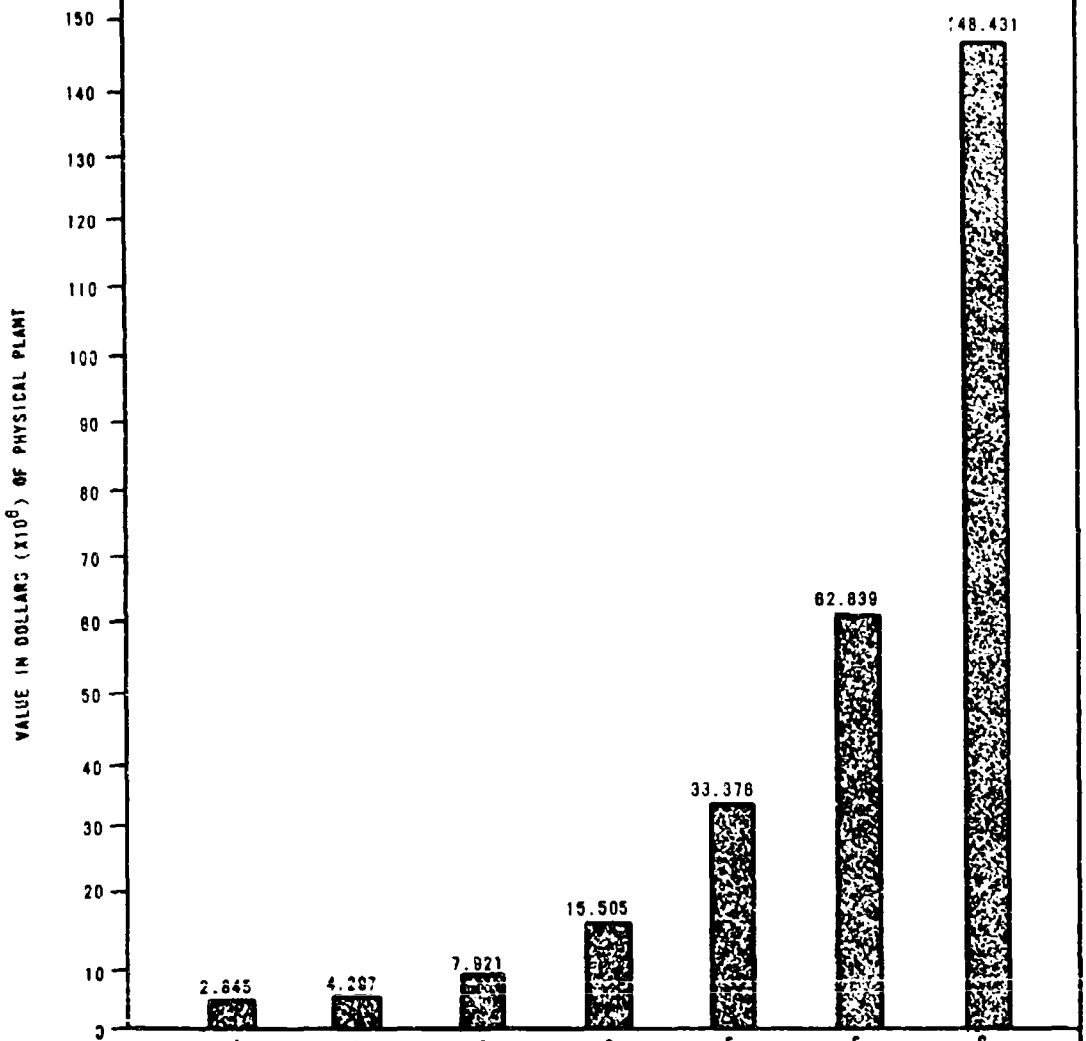
[1] American Universities and Colleges, 1964, American Council on Education.



ENROLLMENT KEY

A = 1-500
B = 501-1000
C = 1001-2000
D = 2001-5000
E = 5001-10,000
F = 10,001-20,000
G = 20,001 & ABOVE

SOURCE: COMPILED FROM AMERICAN UNIVERSITIES AND COLLEGES, 1964

FIG. 5 PHYSICAL PLANT VALUE WITHIN A THROUGH G CATEGORY SCHOOLS

a computer center which will be available to all students enrolled. Taken on a per student basis, the value of the physical plant and the library expenditures are far higher for the small schools. Certain basic expenditures are necessary, however, to operate a college, regardless of the number of students in attendance. A college consisting of only five students would still require a building and certain basic texts and reference books in the library. Under these circumstances the cost per student would be extremely high, but if the school were destroyed, the loss in capability for education would be very low. The destruction of the physical plant and equipment of a large university would constitute much greater loss in terms of capacity for producing trained individuals.

4. Research Products

Figure 5 suggests the magnitude of research conducted by large universities. Destruction of even a small percentage of the nation's "multiversities" would cause a high reduction in the research capability of the higher education system as a whole. The actual amount of money used for research in the large universities is extremely high in comparison to smaller schools, considering the fact that Figure 6 indicates research dollars on a per student basis.

5. Faculty

Figure 7 indicates a higher Ph. D. to total faculty ratio in larger schools than in smaller schools. Although it is dangerous to make assumptions regarding the quality of an education received in a large school versus a small school, the assumption can be made that the larger schools contribute more to general education standards. Loss of large universities would thus potentially result in an overall lowering of education standards across the nation.

6. Graduate Schools

Figure 8 indicates that large schools have a higher proportion of graduate students than small schools. Destruction of predominantly large schools would thus reduce the postgraduate capability of the nation in even greater proportions than the undergraduate capability. Large universities frequently offer doctoral programs in a wide variety of fields. This is not the case with small schools. Loss of large universities would be likely, then, to leave large gaps in certain curricula in terms of capacity for production at the doctoral level.

TABLE 2 CONTRACT RESEARCH DOLLARS PER STUDENT WITHIN A THROUGH G CATEGORY SCHOOLS

SCHOOL SIZE	TOTAL STUDENTS	TOTAL CONTRACT RESEARCH DOLLARS	CONTRACT RESEARCH DOLLARS STUDENT
A	61,510	3,903,945	64.47
B	241,043	5,657,070	23.47
C	371,868	22,735,994	61.14
D	654,823	108,924,248	166.34
E	637,670	440,888,058	691.40
F	737,132	259,203,939	351.64
G	676,519	510,961,157	755.28

SOURCE COMPILED FROM AMERICAN UNIVERSITIES AND COLLEGES, 1964

TABLE 3 PH D TOTAL FACULTY RATIO WITHIN A THROUGH G CATEGORY SCHOOLS

SCHOOL SIZE	N	X Ph.D. FACULTY	X Ph D. FACULTY
A	168	51.77	.308
B	330	103.24	.312
C	252	87.74	.334
D	215	70.58	.328
E	89	29.15	.327
F	45	17.37	.386
G	17	6.87	.404

SOURCE COMPILED FROM AMERICAN UNIVERSITIES AND COLLEGES, 1964

TABLE 4 GRADUATE STUDENTS TO TOTAL STUDENTS RATIOS WITHIN A THROUGH G CATEGORY SCHOOLS

SCHOOL SIZE	TOTAL GRAD STUDENTS	TOTAL STUDENTS	GRAD TOTAL
A	3,702	61,510	.060
B	7,193	241,043	.030
C	23,079	371,868	.062
D	80,654	654,823	.123
E	116,199	637,670	.182
F	146,732	737,132	.199
G	156,495	676,519	.231

SOURCE COMPILED FROM AMERICAN UNIVERSITIES AND COLLEGES, 1964

TABLE 5 GOVERNMENT APPROPRIATIONS PER STUDENT WITHIN A THROUGH G CATEGORY SCHOOLS

SCHOOL SIZE	TOTAL GOV'T APPROP	TOTAL STUDENTS	G A STUDENT
A	4,678,678	61,510	79.215
B	35,095,346	241,043	145.598
C	74,524,738	371,868	200.406
D	288,468,844	654,823	440.529
E	307,215,369	637,670	481.778
F	558,495,571	737,132	757.660
G	566,945,135	676,519	840.989

SOURCE COMPILED FROM AMERICAN UNIVERSITIES AND COLLEGES, 1964

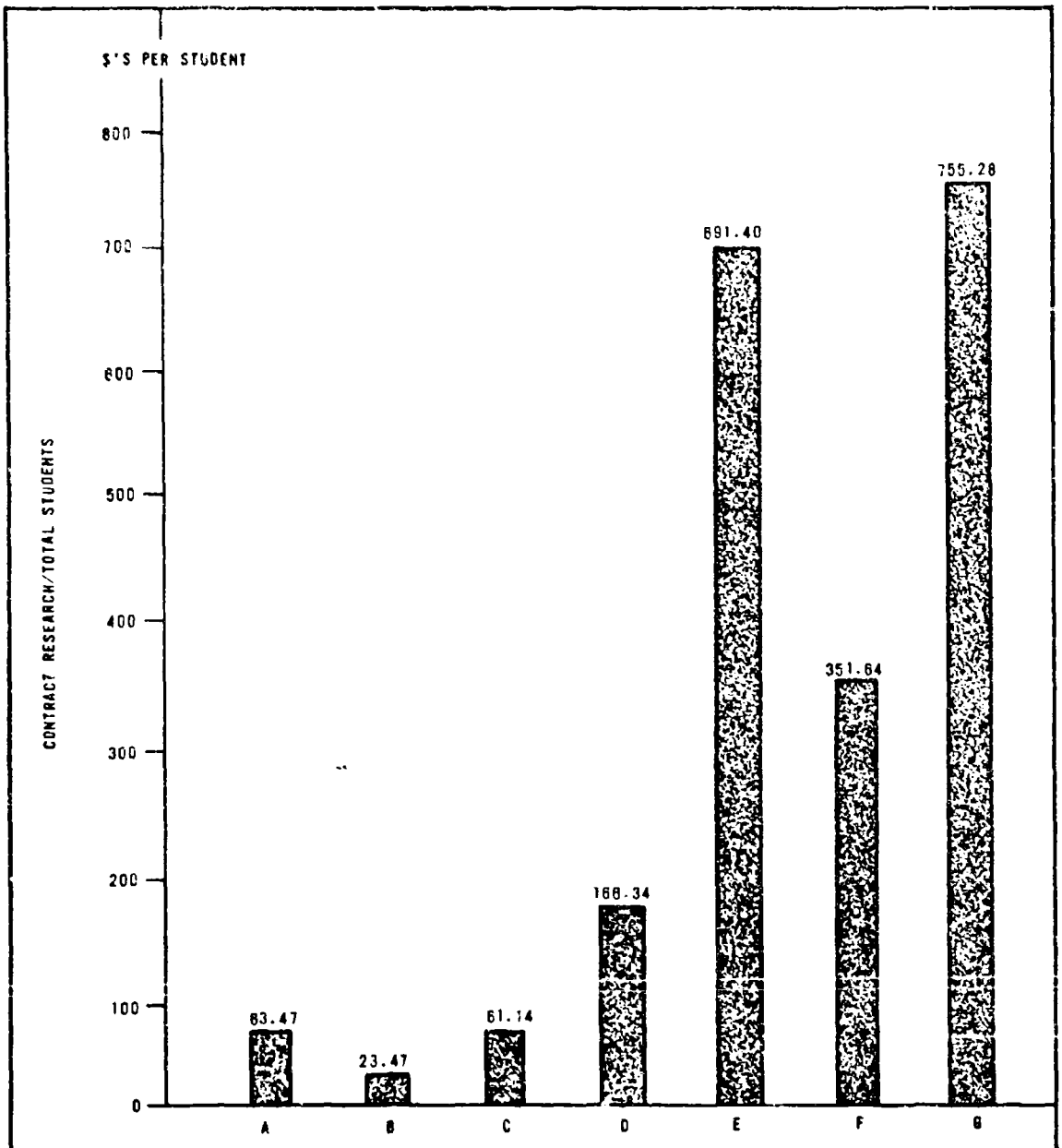


FIG. 6 CONTRACT RESEARCH DOLLARS PER STUDENT BY SCHOOL ENROLLMENT

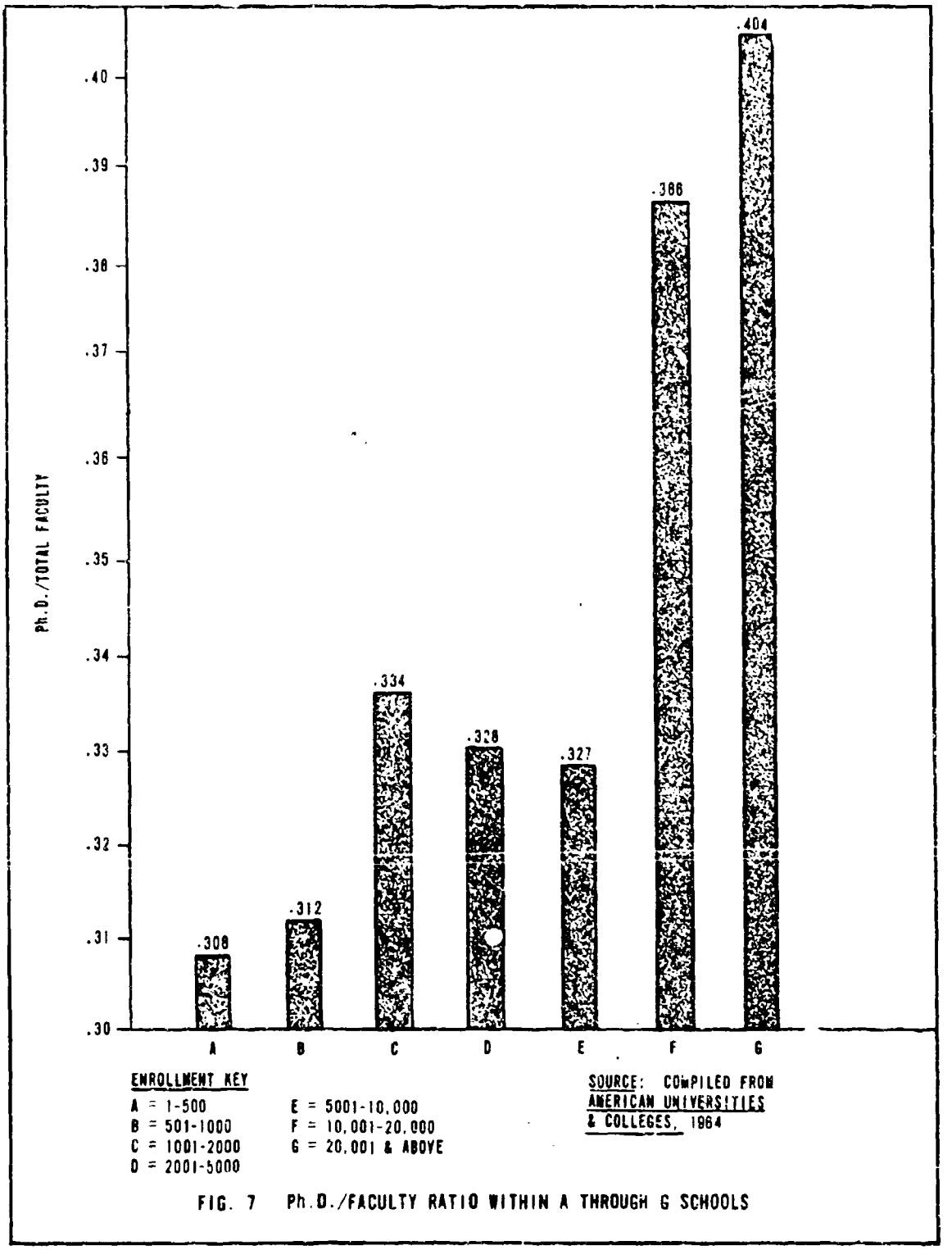


FIG. 7 Ph.D./FACULTY RATIO WITHIN A THROUGH G SCHOOLS

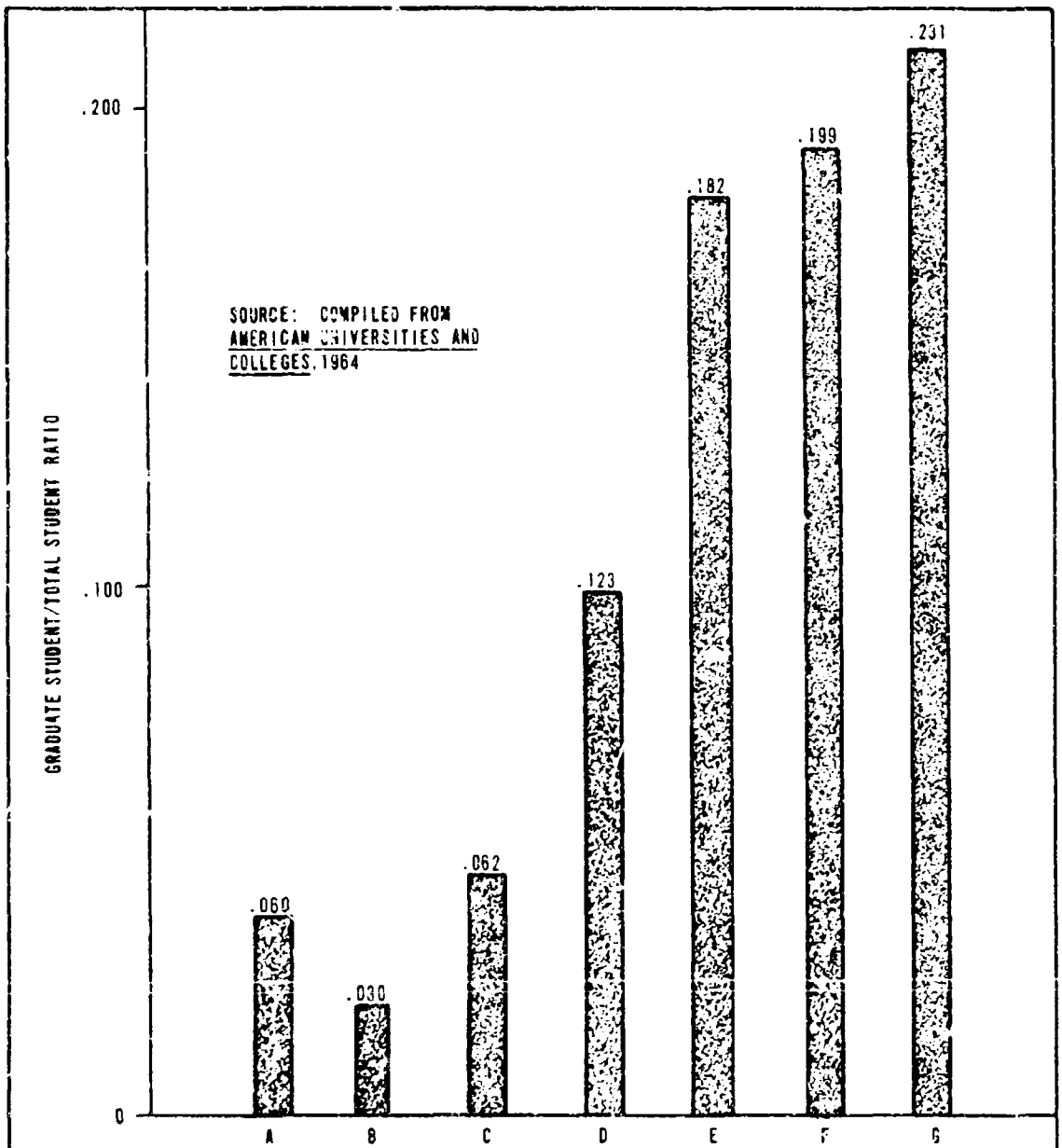


FIG. 8 GRADUATE STUDENTS TO TOTAL STUDENTS RATIOS WITHIN A THROUGH G CATEGORY SCHOOLS

Large universities, even if untouched by the physical damage of a nuclear attack, may suffer some losses in capability from indirect effects of destruction.

For example, Figure 9 indicates that large universities rely heavily upon government appropriation for their operating expenses. In the case of universities with enrollment greater than 10,000, approxmiately thirty-five percent of their income is in the form of government appropriations. Disruption of state governments, the federal government, and the entire economic structure may restrict or divert appropriation money normally allocated to large universities. Even if the governmental agencies are intact and able to make allocation decisions, money may simply not be available for higher education. Heavy reliance by the populace on welfare and the problem of resumption of production in critical industries may result in high government financial assistance in these areas.

C. THE VALUE OF SMALL COLLEGES--ELASTICITY

The previous discussion has indicated that higher education vulnerabilities exist because the system configuration is such that it could be easily damaged by a nuclear attack. It is safe to assume that the vulnerabilities will lead to a loss of higher education capability, perhaps not in all the products of the higher education system, but certainly in general. Like any system involving a broad spectrum of men, equipment, and procedures, higher education has some built-in elasticity. It is flexible and adaptable, and maintains a degree of latent capability. Many schools are not operating at peak capacity, and many students could change curricula mid-stream should the need arise. A greater portion of the remaining population could be encouraged to attend school if necessary. It is quite definite that higher education elasticity exists, and that it will play a major role in the system's ability to meet post-attack demands. It is also definite that accurate assessment of post-attack capability presupposes knowledge of the prevailing elasticity. It is necessary to understand its nature, how it may operate, what its limits are, and its consequences. This subsection presents a preliminary discussion of the nature of system elasticity.

Up to this point, primary concern has been with the attributes of large universities and their characteristics vulnerability. Attention is now shifted to small and intermediate size schools and their characteristic survivability.

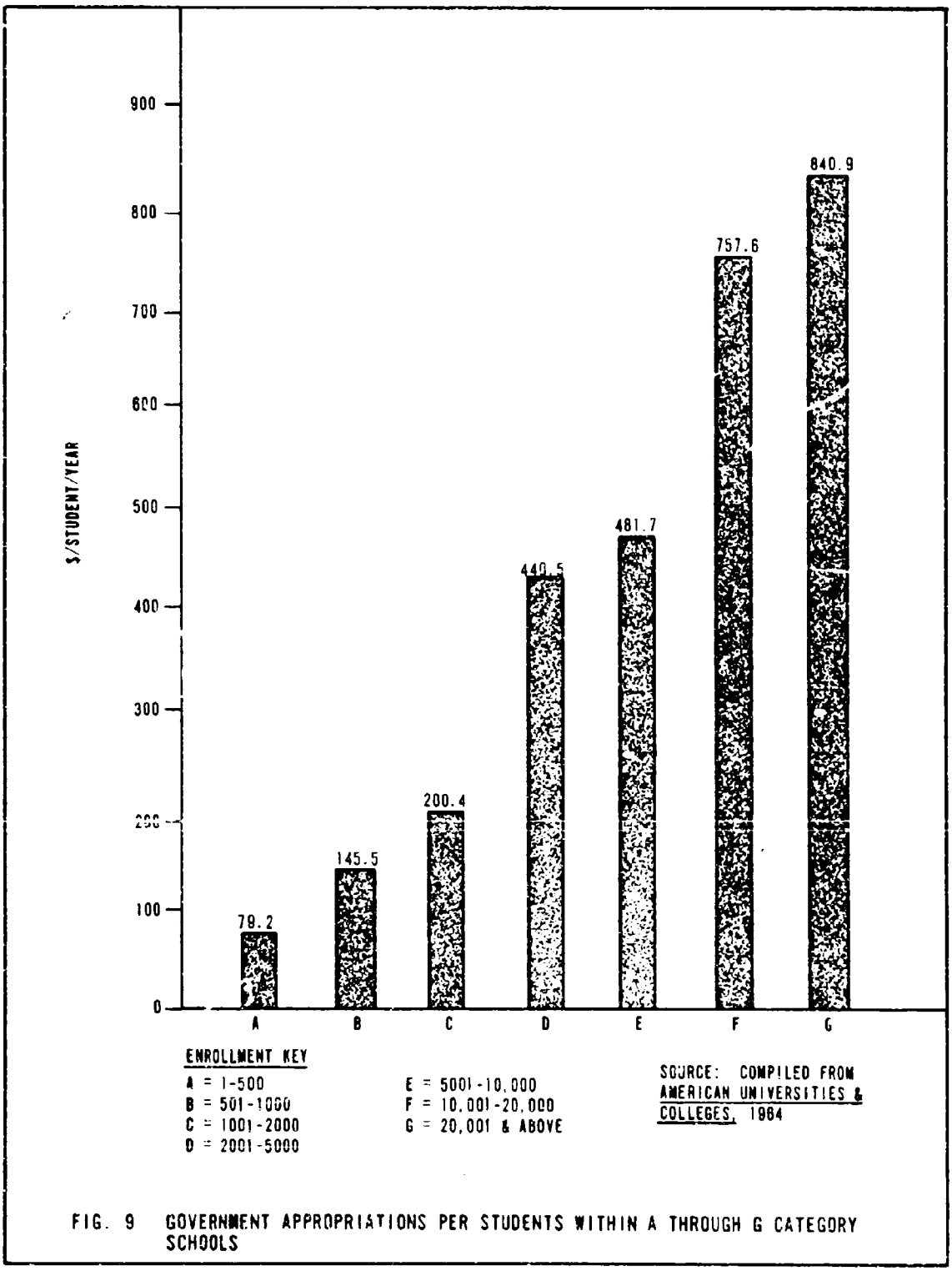


FIG. 9 GOVERNMENT APPROPRIATIONS PER STUDENTS WITHIN A THROUGH G CATEGORY SCHOOLS

Small colleges differ considerably from large universities in several respects. They have a lower yearly budget; they have less equipment, faculty, and diversity of products; and they exist in far greater numbers. Many of the very factors that contribute to the vulnerability of large universities contribute, in reciprocal fashion, to the survivability of small colleges. These factors include the following:

1. Geographic Distribution

Small and intermediate schools are more evenly distributed over the nation than are large schools. This quality renders them less vulnerable since they will not be damaged en masse through an attack directed at any one geographic sector or at cities.

2. Sheer Quantity

Small schools exist in far greater numbers than large schools. Thus, many are likely to remain relatively undamaged in view of their wide geographic distribution.

3. Potential Elasticity

Library expenditures per student and value of the physical plant per student are much higher for small schools than for large schools. The reason for this trend was cited in the previous subsection as the requirement of certain basic expenditures in order to operate a college. Once certain basic necessities are procured, they can be used by many students, and the costs of expanding to accommodate more students are considerably lowered. Small colleges should thus be able to accommodate more students under emergency conditions, with minimum additional expense. In addition, small schools have more dormitory space available per student than larger schools and thus could probably house more students than they presently do. Undoubtedly, lack of dormitory space in large schools reflects practices of commuting and private housing, but many of these same practices could be applied to small schools should the need arise.

Small colleges also show less dependence on government appropriations for their income. The income in the case of smaller schools frequently comes from private organizations, churches, and endowments--all of which are less likely than the government to divert their funds for other use. Ikle reports that

endowments to medieval universities actually increased during the Black Death of the fourteenth century.[1]

Smaller schools tend toward higher faculty-to-student ratios, i. e., fewer students per faculty member than large schools. Implications cannot be drawn regarding differences in quality of instruction, for large universities may simply be exercising the practice of mass lecturing via television or other communication devices. The important point is that smaller schools could adopt mass instructional programs and have sufficient faculty to greatly expand the number of students without appreciable drops in existing quality of instruction.

One characteristic of small schools may reduce elasticity. Small schools do not have wide diversity in their curriculum structure. The majority tend to be heavily oriented toward liberal arts or education, with a few "specialty" schools such as theological seminaries. Problems will thus arise in attempting to provide additional capacity in curricula such as the physical sciences. Certain curricula are more easily disrupted than others and therefore, are less elastic. The physical sciences, for example, are not extremely elastic due to the fact that they require laboratory equipment and special facilities for even the most elementary courses. Liberal arts and the social sciences are less demanding and hence more elastic.

Solutions to this problem may be possible, however. Small colleges, even though they specialize in liberal arts or education, usually have a wide range of faculty. Teachers' colleges, for example, have small departments in many of the physical sciences. These departments could conceivably be expanded around a nucleus or combined across different schools to bring to one place the necessary combined talent and equipment for operation similar to a university department. In addition, the more flexible curricula of small colleges could utilize classroom facilities in hotels or other available housing to free laboratory and classroom space for more demanding curricula.

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[1] Ikle, F. C. The Social Impact of Bomb Destruction. University of Oklahoma Press, Norman, Oklahoma, 1958.

D. OVERVIEW

Vulnerabilities to attack disruption exist in the higher education system primarily as a function of the geographic distribution of the member colleges and universities. The system is characterized by extreme clustering of facilities in particular areas.

Specific curricula vulnerabilities result from geographic dependencies for trained individuals in a given profession. Due to facility clustering, specific states and geographic sectors produce disproportionate quantities of college graduates trained in particular professions. Nuclear destruction in these centers of education will thus create future skill deficits for the entire nation.

General system vulnerabilities occur due to the geographic location of the nation's largest universities. These schools are few in number but produce many graduates. Not only do they process vast numbers of students but they make high contributions in research and consultation to society. They have the most advanced facilities and equipment, the highest trained faculty, the broadest range of curricula. Because of their research and leadership contributions, they may constitute strategic targets in and of themselves. This is further accentuated by the fact that they are located primarily in large metropolitan areas and are quite likely to receive heavy damage or complete destruction even if they are not targets themselves. Elasticity constitutes an important system factor in the determination of post-attack capability. Post-attack capability cannot be assessed on the basis of pre-attack capability minus the capability lost as a function of damage. The higher education system contains certain flexibilities and latent capability which could be exploited if necessary toward meeting post-attack damands. A high degree of elasticity appears to be presented in the form of small colleges. These schools, present in large numbers and distributed relatively evenly throughout the nation, should provide a cushion effect if high destruction occurs in the large universities.

The assertions of this chapter were based upon a systematic inspection of today's higher education system. They are not bound to any particular pattern of attack, and, with the exception of occasional reference to large cities as likely targets, assume little with respect to attack characteristics. They are thus generalizable across a wide range of attack situations. Generalizability

is frequently purchased at the expense of certainty, however; so steps were taken to verify the assertions before adopting them as facts upon which further research would be based. Chapter 4 describes the verification process and reports its conclusions.

CHAPTER IV. NATIONWIDE DAMAGE ASSESSMENT

A. PURPOSE OF THE NATIONWIDE ASSESSMENT

The research presented in this chapter has two purposes. First, it is intended to substantiate the assertions of Chapter 3 with respect to the existence of system vulnerabilities and the "survivability" of small schools by assessing the nature of higher education capability remaining after a hypothetical attack. Second, it is designed to provide essential information for an analysis of system elasticity and the development of remedial countermeasures designed to exploit elasticity and increase the system's post-attack capability. The first of these purposes is self-explanatory. The second requires some clarification at this point.

The study places emphasis upon the idea that one of the most effective techniques for expediting system recovery will be to take advantage of existing elastic properties within the system. It will be more efficient, for example, to expand the operations of surviving small colleges than to rebuild large universities which have been seriously damaged (at least in the early phases of post-attack.)

In order to study the properties of potential elasticity existing within any one school, or a sample of schools, something must be known regarding the condition of the remainder of the system. Certainly it is both practical and desirable to study the damage posture of each school in a sample from the standpoint of disruption of service and component damage, but this alone will not produce a completely accurate picture in terms of utility of elasticity. For example, a particular medical school may suffer little damage from the direct effects of a bomb in its metropolitan vicinity, and yet experience extreme production problems in the post-attack period due to wide-spread damage to other medical schools in the same area or in the nation as a whole. The elasticity factors inherent in medical schools may, under these conditions, be of crucial importance, but this would not be disclosed if generalizations were made solely on the basis of damage assessment in this school alone. It was necessary, therefore, to obtain an indication of overall damage across the entire system, before attempting a more thorough and detailed analysis with respect to individual schools.

B. PROCEDURE OF ASSESSMENT

The Five City Study, a detailed point-by-point analysis recently undertaken by the Office of Civil Defense, provided a convenient framework for conducting this portion of the research. The initial attack pattern specified for the Five City Study represents a concrete situation analogous to an actual attack.

The procedure involved superimposing the Five City attack pattern on a series of maps indicating the exact geographic location of all higher education facilities in the nation. Damage radii were drawn around the location of each bomb according to the bomb yield and whether the burst occurred in the air or on the ground. Damage to each school was determined on the basis of the distance of the school from the burst, and the criteria sited in Tables 6 and 7. Schools falling within the severe damage area were considered totally destroyed in terms of their future ability to produce trained individuals, and those falling within the moderate damage area were considered operative to 50% of their original capability. Complete capability was inferred for anything less than moderate damage. All losses and remaining capability were expressed in terms of "capacity for production". This refers to the size of student enrollment which may be handled after damage. The resulting totals were expressed according to the descriptive breakdowns found most meaningful in Study Phase I, i. e. by geographic sector, type of school (as indicated by size of pre-attack enrollment) and across specific curricula.

C. RESULTS AND DISCUSSION

The results are presented in Figures 10 to 17 and are summarized in Tables 8 and 9. The results indicate a total loss of 31.3% (Table 9) of the nation's ability to produce college trained individuals. It is necessary to examine these losses, however, in terms of the type of schools damaged and their locations. Of prime concern is the fact that while approximately 77% of the schools destroyed were relatively small (enrollments of less than 5,000 students), these schools account for only 23% of the loss in capacity for production (Figures 10 and 12.) This discrepancy is attributed to one of the primary vulnerabilities of the higher education system. It will be recalled from Chapter 3 that large schools, while few in number, account for a major portion of the system capacity. These schools are located predominately in or near large cities and similar probable targets. Figures 10, 11, and 12 indicate that the Five City "attack"

TABLE 6 SEVERE DAMAGE CRITERIA

CALCULATED FROM: THE EFFECTS OF NUCLEAR WEAPONS, 1962

CRITICAL RANGES FOR GROUND AND AIR BURSTS OF VARYING INTENSITY

		500KT	1000KT	1500KT	2000KT	3000KT	4000KT	5000KT	10,000KT
WALL-BEARING MASONRY BUILDING	(PSI) MAX. OVERPRESSURE	5-6	5-6	5-6	5-6	5-6	5-6	5-6	5-6
	GROUND BURST RANGE (MI.)	2.15	2.7	3.1	3.4	3.93	4.33	4.6	6
	AIR BURST RANGE (MI.)	3.20	4.3	4.9	5.2	6.20	6.75	7.4	9.25
MULTISTORY WALL-BEARING BUILDING	(PSI) MAX. OVERPRESSURE	8-11	8-11	8-11	8-11	8-11	8-11	8-11	8-11
	GROUND BURST RANGE (MI.)	1.7	2.1	2.4	2.7	3.1	3.4	3.6	4.6
	AIR BURST RANGE (MI.)	2.5	3.2	3.6	3.9	4.5	5.0	5.4	6.75
REINFORCED CONCRETE, CONCRETE WALLS, SMALL WINDOW AREA	(PSI) MAX. OVERPRESSURE	11-15	11-15	11-15	11-15	11-15	11-15	11-15	11-15
	GROUND BURST RANGE (MI.)	1.4	1.8	2.1	2.25	2.6	2.85	3.1	3.9
	AIR BURST RANGE (MI.)	2.0	2.5	2.8	3.29	3.6	4.00	4.4	5.5
AVERAGE RANGES FOR ABOVE 3 BUILDINGS	GROUND BURST (MI.)	1.75	2.2	2.55	2.78	3.27	3.52	3.8	4.8
	AIR BURST (MI.)	2.56	3.33	3.90	4.10	4.70	5.25	5.73	7.16

*DEGREE WHICH PRECLUDES FURTHER USE OF STRUCTURE FOR ITS INTENDED PURPOSES WITHOUT ESSENTIALLY COMPLETE RECONSTRUCTION. COLLAPSE IS GENERALLY IMPLIED.

TABLE 7 MODERATE* DAMAGE CRITERIA

CALCULATED FROM: THE EFFECTS OF NUCLEAR WEAPONS, 1962

CRITICAL RANGES FOR GROUND AND AIR BURSTS OF VARYING INTENSITY

		500KT	1000KT	1500KT	2000KT	3000KT	4000KT	5000KT	10,000KT
WALL-BEARING MASONRY BUILDING	(PSI) MAX. OVERPRESSURE	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4
	GROUND BURST RANGE (MI.)	2.9	3.6	4.2	4.6	5.3	5.8	6.25	8.00
	AIR BURST RANGE (MI.)	4.6	6.0	7.0	7.7	8.8	9.7	10.50	13.00
MULTISTORY WALL-BEARING BUILDING	(PSI) MAX. OVERPRESSURE	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7
	GROUND BURST RANGE (MI.)	2.0	2.5	2.8	3.1	3.5	3.8	4.2	5.40
	AIR BURST RANGE (MI.)	3.0	3.8	4.3	4.8	5.4	6.0	6.5	8.25
REINFORCED CONCRETE, CONCRETE WALLS, SMALL WINDOW AREA	(PSI) MAX. OVERPRESSURE	8-10	8-10	8-10	8-10	8-10	8-10	8-10	8-10
	GROUND BURST RANGE (MI.)	1.7	2.1	2.4	2.7	3.1	3.4	3.6	4.6
	AIR BURST RANGE (MI.)	2.5	3.2	3.8	3.9	4.5	5.0	5.4	6.75
AVERAGE RANGES FOR ABOVE 3 BUILDINGS	GROUND BURST (MI.)	2.20	2.70	3.13	3.47	3.97	4.37	4.7	6.00
	AIR BURST (MI.)	3.43	4.33	4.97	5.47	6.23	6.90	7.46	9.33

* DEGREE WHICH PRECLUDES EFFECTIVE USE OF STRUCTURE FOR ITS INTENDED PURPOSES UNLESS MAJOR REPAIRS ARE MADE

TABLE 8 NATIONWIDE ANALYSIS -- DATA SUMMARY

SIZE CATEGORIES	A	B	C	D	E	F	G	TOTAL
TOTAL NUMBER OF SCHOOLS PRE-ATTACK	184	329	268	214	90	54	22	1161
NUMBER OF SCHOOLS DESTROYED	49.5	59.5	49	35.5	27.5	19	12	252
PERCENT OF SCHOOLS DESTROYED	26.9	18	18.2	16.5	30.5	35.1	54.5	21.7
NUMBER REMAINING SCHOOLS	134.5	269.5	219	178.5	62.4	35	10	909
PERCENT REMAINING SCHOOLS	73.1	82	81.8	83.5	69.5	64.9	45.5	78.3
PRE-ATTACK PERCENTAGE DISTRIBUTION OF TOTAL	15.8	28.3	28.1	18.4	7.7	4.6	1.8	100
POST-ATTACK PERCENTAGE DISTRIBUTION OF TOTAL	14.7	29.6	24.1	19.6	6.8	3.8	1.1	100
TOTAL CAPACITY FOR PRODUCTION PRE-ATTACK	61,510	241,043	371,868	654,823	634,670	737,132	676,519	3,380,565
CAPACITY FOR PRODUCTION LOST	15,766	43,192	72,375	111,222	187,165	252,324	377,027	1,059,071
% CAPACITY FOR PRODUCTION LOST	25.6	17.9	19.5	17	29.4	34 2	55.7	31.3
CAPACITY FOR PRODUCTION REMAINING	45,744	197,851	299,493	543,601	450,505	484,808	299,492	2,321,494
% CAPACITY FOR PRODUCTION REMAINING	74.4	82.1	80.5	83	70.6	65.8	44.3	68.7
PRE-ATTACK PERCENTAGE DISTRIBUTION OF TOTAL	1 8	7.1	11	19.3	18.8	21.8	20	100
POST-ATTACK PERCENTAGE DISTRIBUTION OF TOTAL	1.9	8.5	12.9	23.4	19.4	20.8	12.9	100
LOSSES IN NATIONAL CAPACITY FOR PRODUCTION AS FUNCTION OF SIZE CATEGORY	.5	1.3	2.2	2.5	5.5	7.5	11.2	31.3
REMAINING NATIONAL CAPACITY FOR PRODUCTION AS FUNCTION OF SIZE CATEGORY	1.3	5.8	8.8	16.8	13.3	14 3	8.8	68.7

TABLE 9 POST-ATTACK CAPACITY FOR PRODUCTION BY STATE, PERCENTAGE LOST AND REMAINING

STATE	CAPACITY FOR PRODUCTION PERCENTAGE LOST	CAPACITY FOR PRODUCTION REMAINING	CAPACITY FOR PRODUCTION PRE-ATTACK
ALABAMA	2.4	97.6	37,408
ARIZONA	47.4	52.6	33,236
ARKANSAS	9.0	91.0	26,818
CALIFORNIA	49.3	50.7	254,257
COLORADO	23.4	76.6	43,849
CONNECTICUT	42.2	57.8	54,591
DELAWARE	12.0	88.0	5,386
DISTRICT OF COLUMBIA	80.4	19.6	36,685
FLORIDA	29.8	70.2	51,452
GEORGIA	6.0	91.0	45,786
IDAHO	0.0	100.0	8,916
ILLINOIS	16.5	83.5	183,042
INDIANA	7.1	92.9	101,865
IOWA	3.3	96.7	58,312
KANSAS	20.8	79.2	51,979
KENTUCKY	0.0	100.0	47,872
LOUISIANA	21.8	78.2	62,519
MAINE	33.4	66.6	9,816
MARYLAND	1.3	98.7	49,310
MASSACHUSETTS	61.0	39.0	131,782
MICHIGAN	27.5	72.5	138,896
MINNESOTA	60.4	39.6	73,805
MISSISSIPPI	7.4	92.6	20,313
MISSOURI	41.5	58.5	81,555
MONTANA	6.2	93.8	14,610
NEBRASKA	36.6	63.4	36,697
NEVADA	0.0	100.0	3,661
NEW HAMPSHIRE	11.5	88.5	11,382
NEW JERSEY	11.0	89.0	94,130
NEW MEXICO	51.2	48.7	17,716
NEW YORK	50.1	49.9	491,642
NORTH CAROLINA	2.9	97.1	87,872
NORTH DAKOTA	66.1	33.9	13,008
OHIO	23.2	76.8	179,443
OKLAHOMA	12.6	87.4	54,623
OREGON	51.8	48.2	40,308
PENNSYLVANIA	33.1	66.9	207,780
RHODE ISLAND	0.0	100.0	16,411
SOUTH CAROLINA	9.5	90.5	28,031
SOUTH DAKOTA	6.0	94.0	14,722
TENNESSEE	38.0	61.0	85,539
TEXAS	34.5	65.5	156,803
UTAH	42.6	58.0	36,138
VERMONT	0.0	100.0	8,058
VIRGINIA	15.6	84.4	47,784
WASHINGTON	7.7	92.3	53,396
WEST VIRGINIA	0.0	100.0	30,847
WISCONSIN	33.0	67.0	80,204
WYOMING	0.0	100.0	4,628

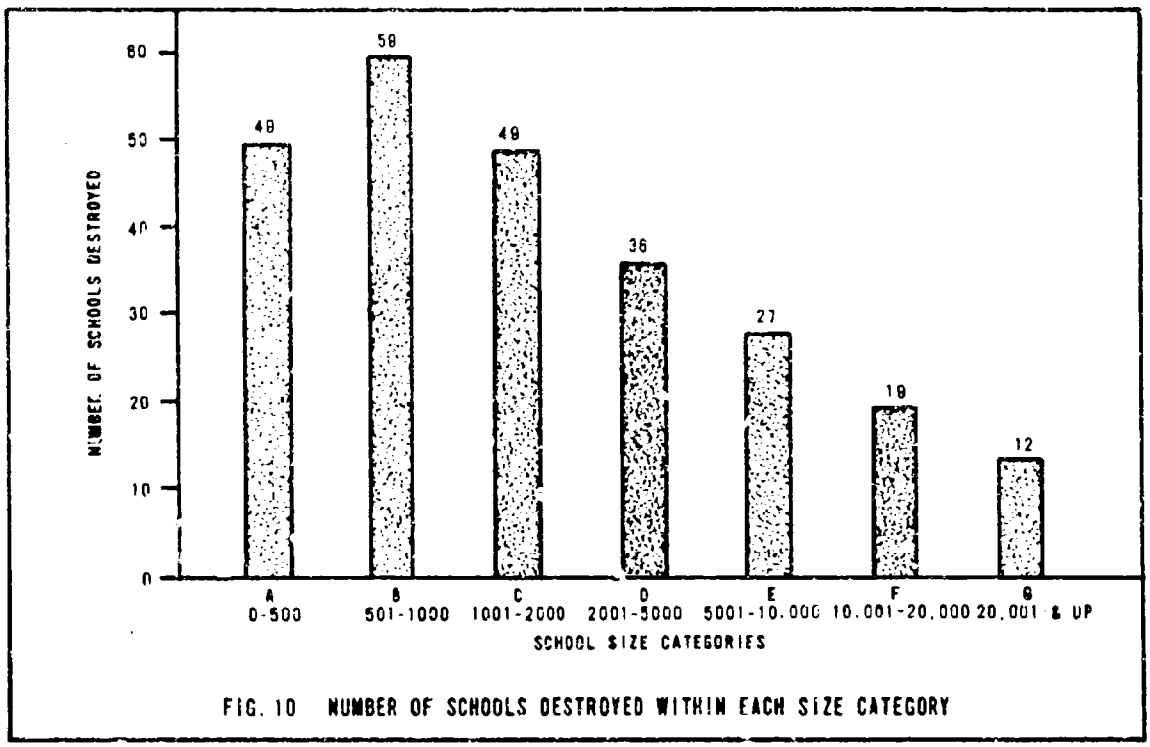

FIG. 10 NUMBER OF SCHOOLS DESTROYED WITHIN EACH SIZE CATEGORY

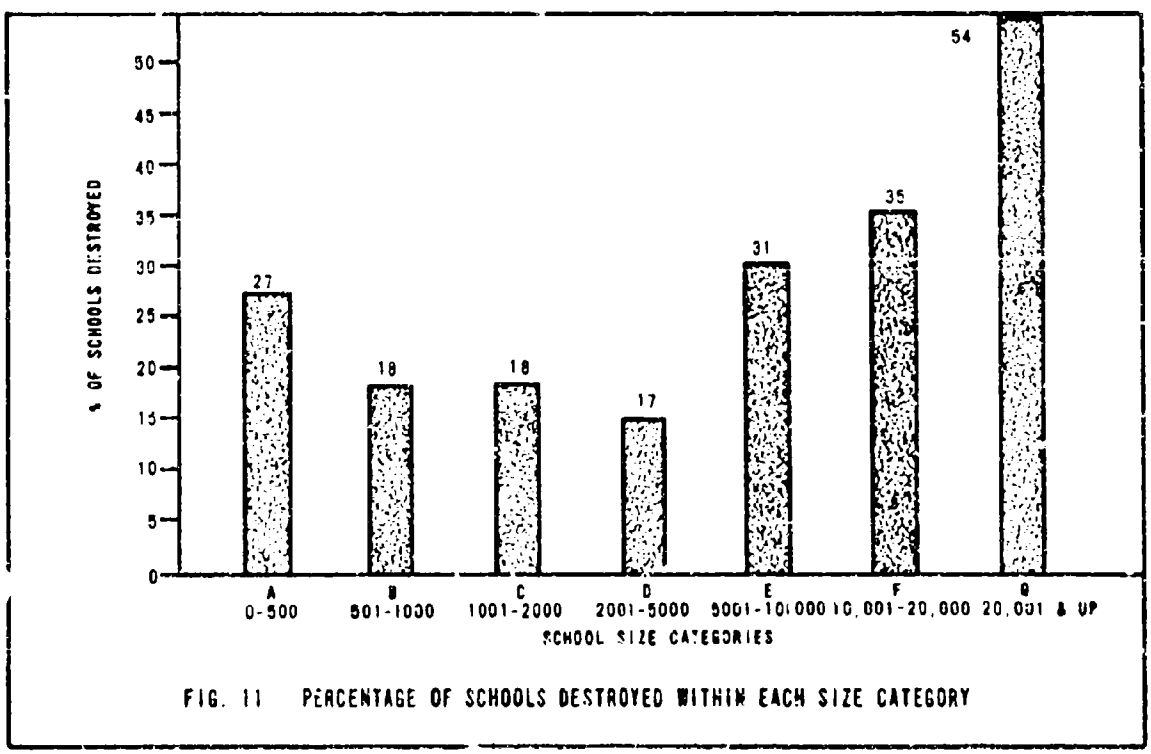

FIG. 11 PERCENTAGE OF SCHOOLS DESTROYED WITHIN EACH SIZE CATEGORY

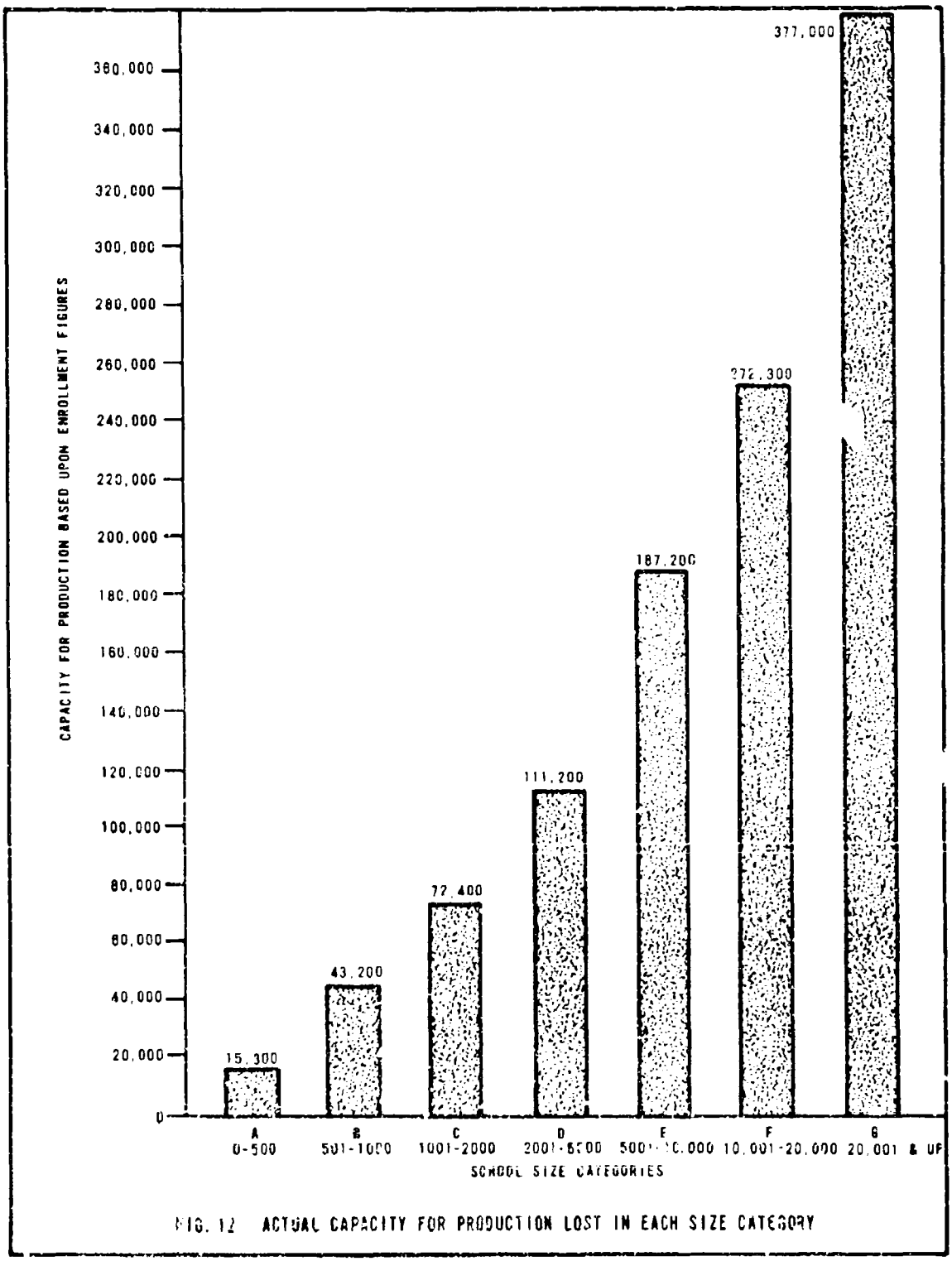

FIG. 12 ACTUAL CAPACITY FOR PRODUCTION LOST IN EACH SIZE CATEGORY

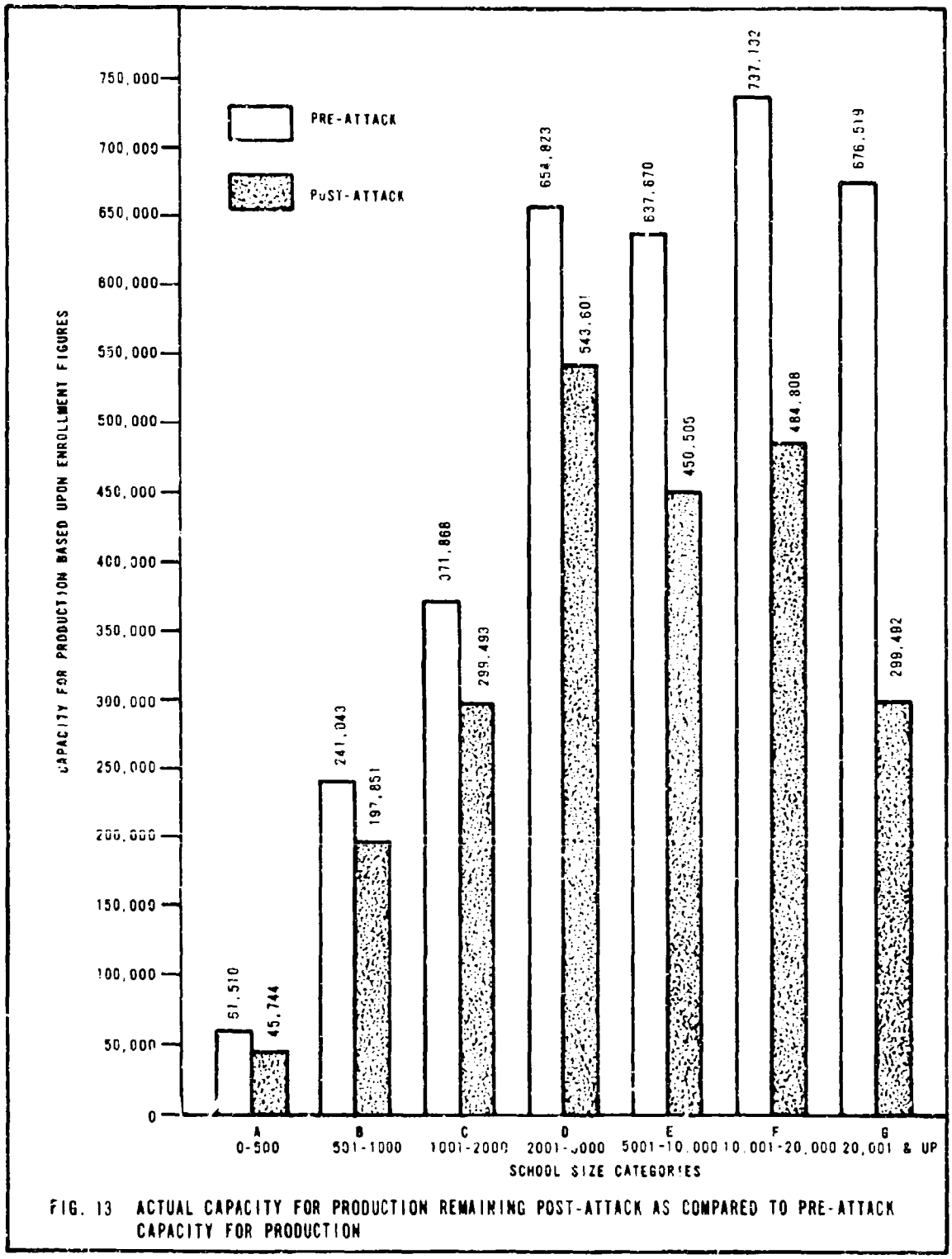

FIG. 13 ACTUAL CAPACITY FOR PRODUCTION REMAINING POST-ATTACK AS COMPARED TO PRE-ATTACK CAPACITY FOR PRODUCTION

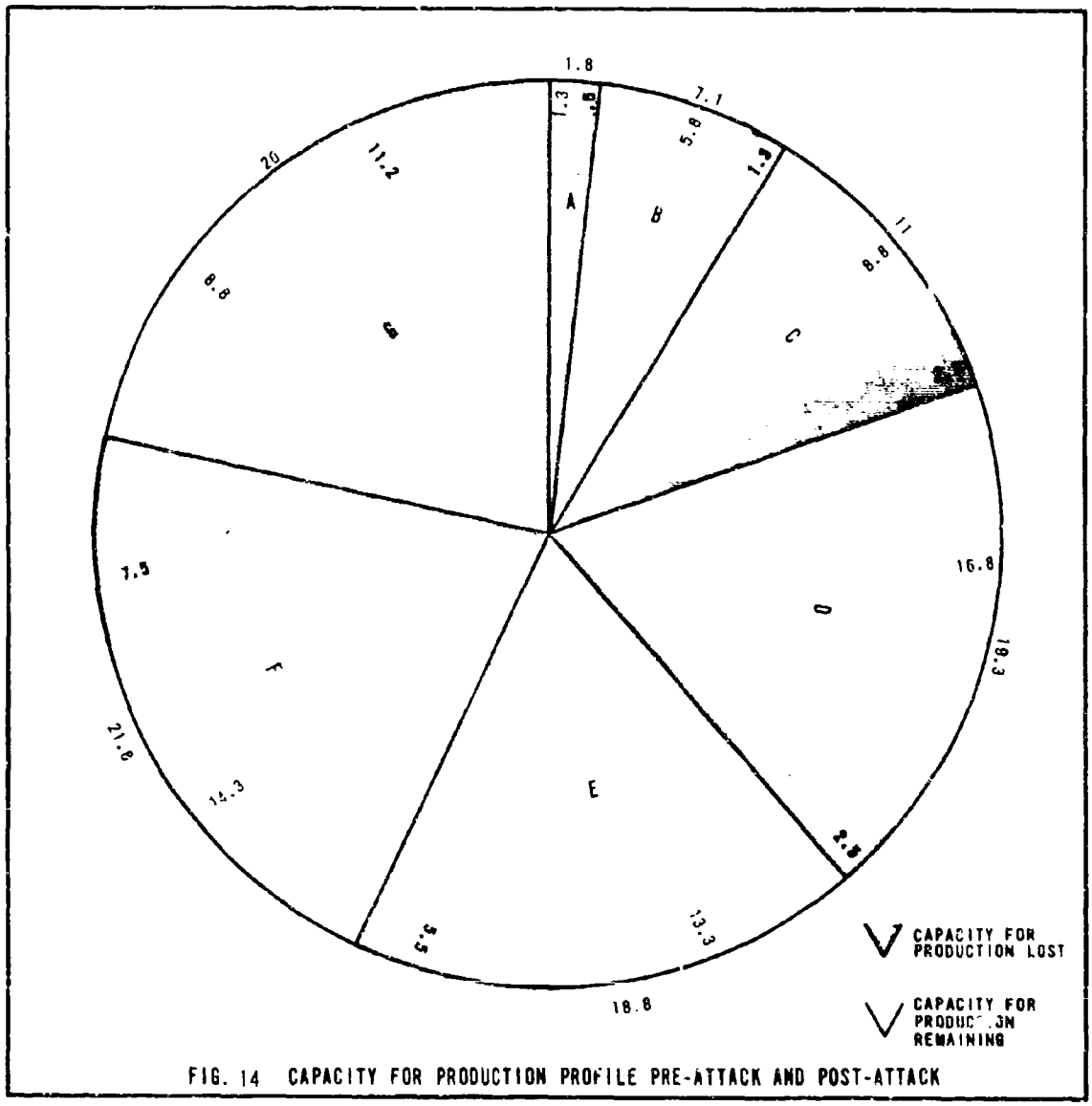

FIG. 14 CAPACITY FOR PRODUCTION PROFILE PRE-ATTACK AND POST-ATTACK

	A	B	C	D	E	F	G
PRE-ATTACK DISTRIBUTION	1.8	7.1	11	18.3	18.8	21.8	20
POST-ATTACK DISTRIBUTION	1.9	8.5	12.8	23.4	18.4	20.8	12.9

FIG. 15 DISTRIBUTION OF SCHOOLS BY SIZE CATEGORIES PRE- AND POST-ATTACK

FIG. 16 CAPACITY FOR PRODUCTION LOST -- POST-ATTACK -- PERCENTAGES BY STATE

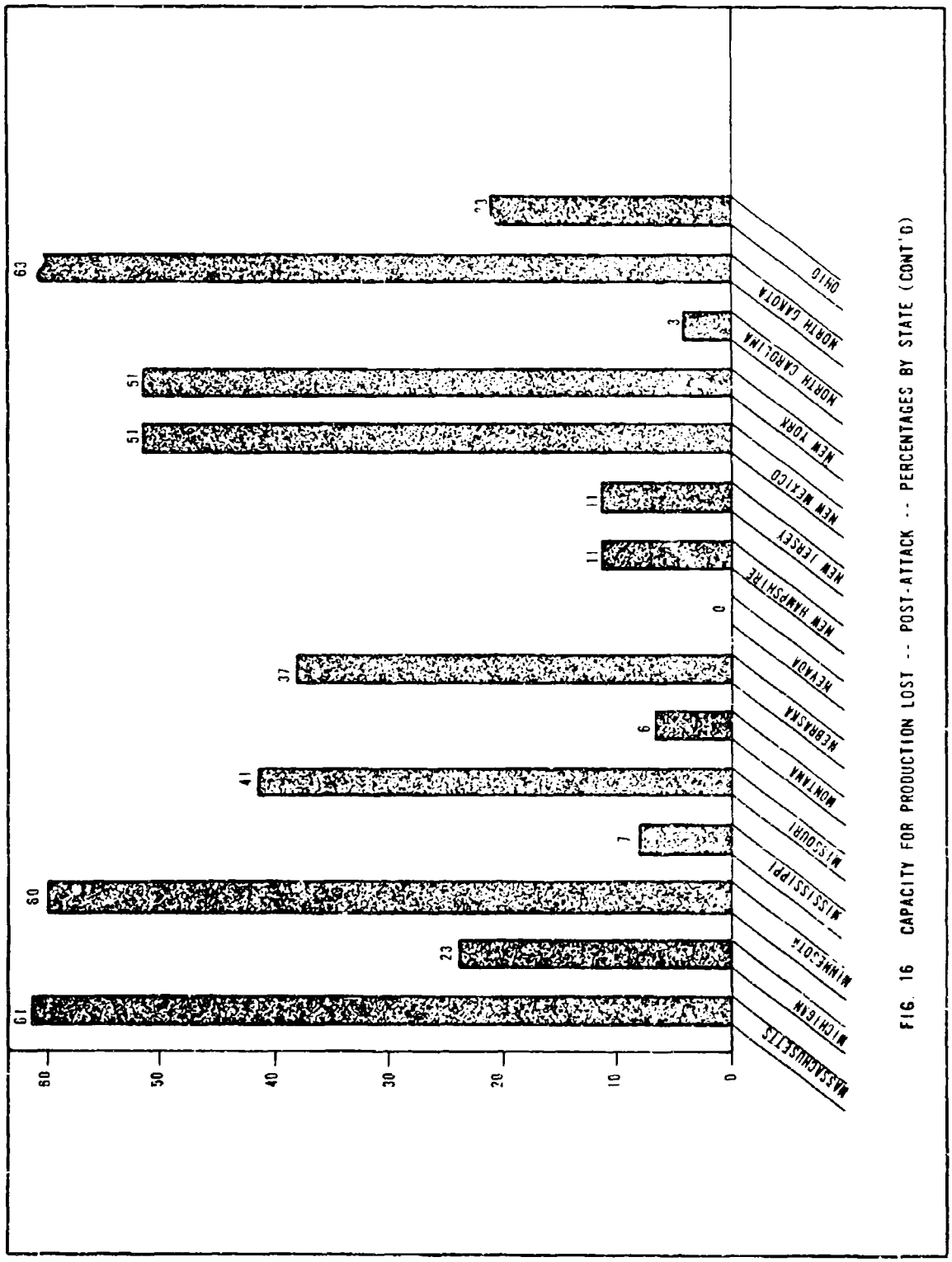

FIG. 16 CAPACITY FOR PRODUCTION LOST -- POST-ATTACK -- PERCENTAGES BY STATE (CONT'D)

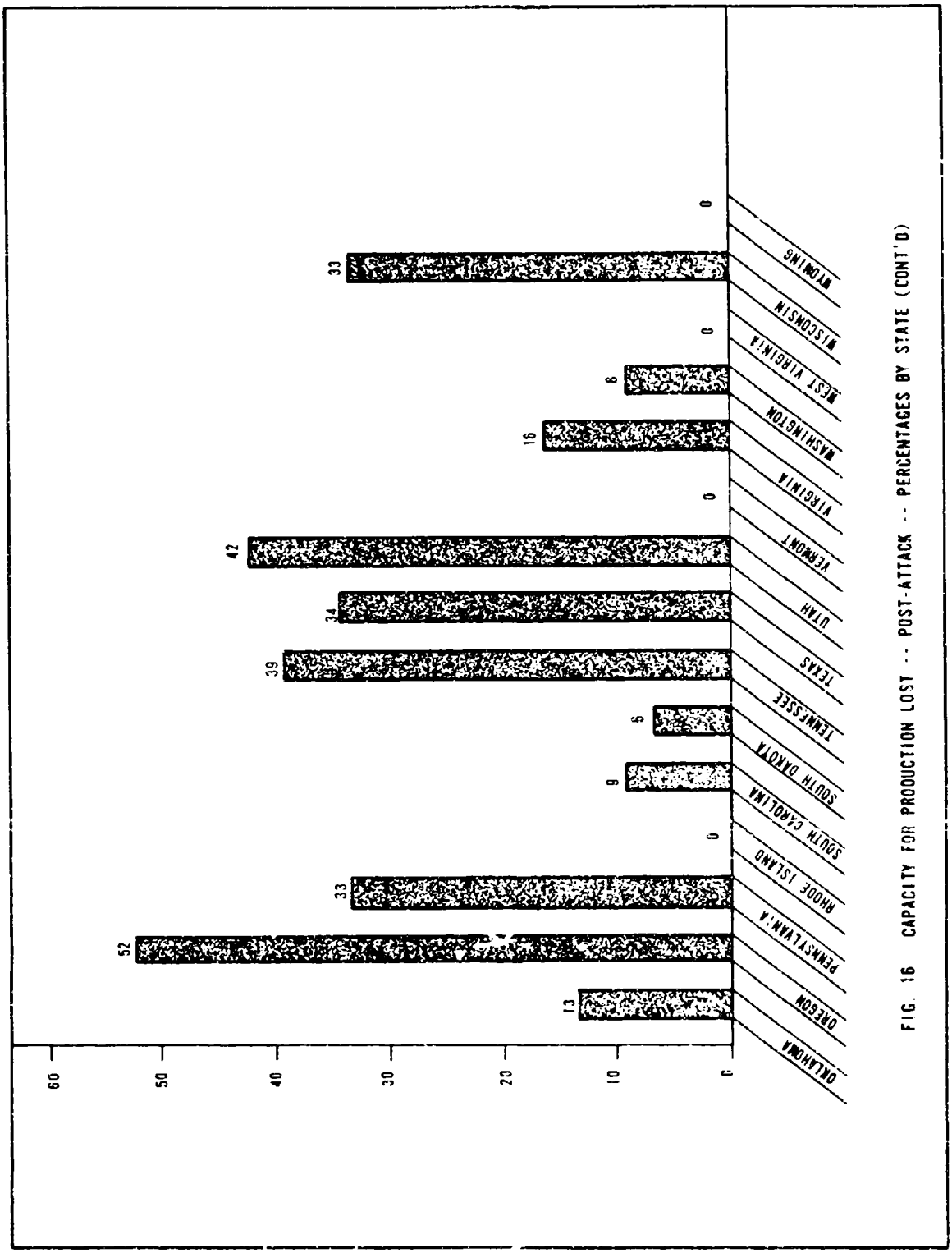

FIG. 16 CAPACITY FOR PRODUCTION LOST -- POST-ATTACK -- PERCENTAGES BY STATE (CONT'D)

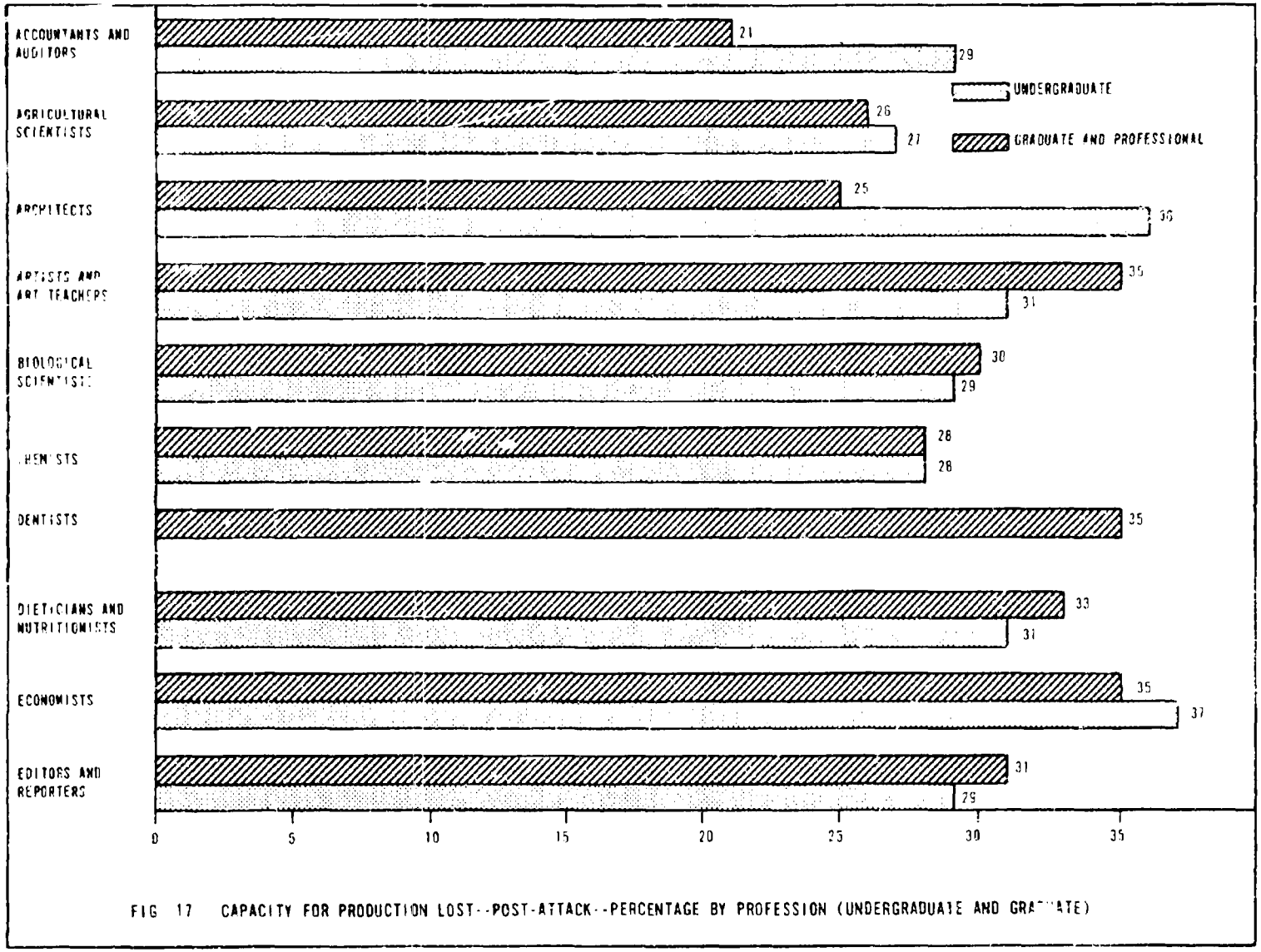

FIG 17 CAPACITY FOR PRODUCTION LOST--POST-ATTACK--PERCENTAGE BY PROFESSION (UNDERGRADUATE AND GRADUATE)

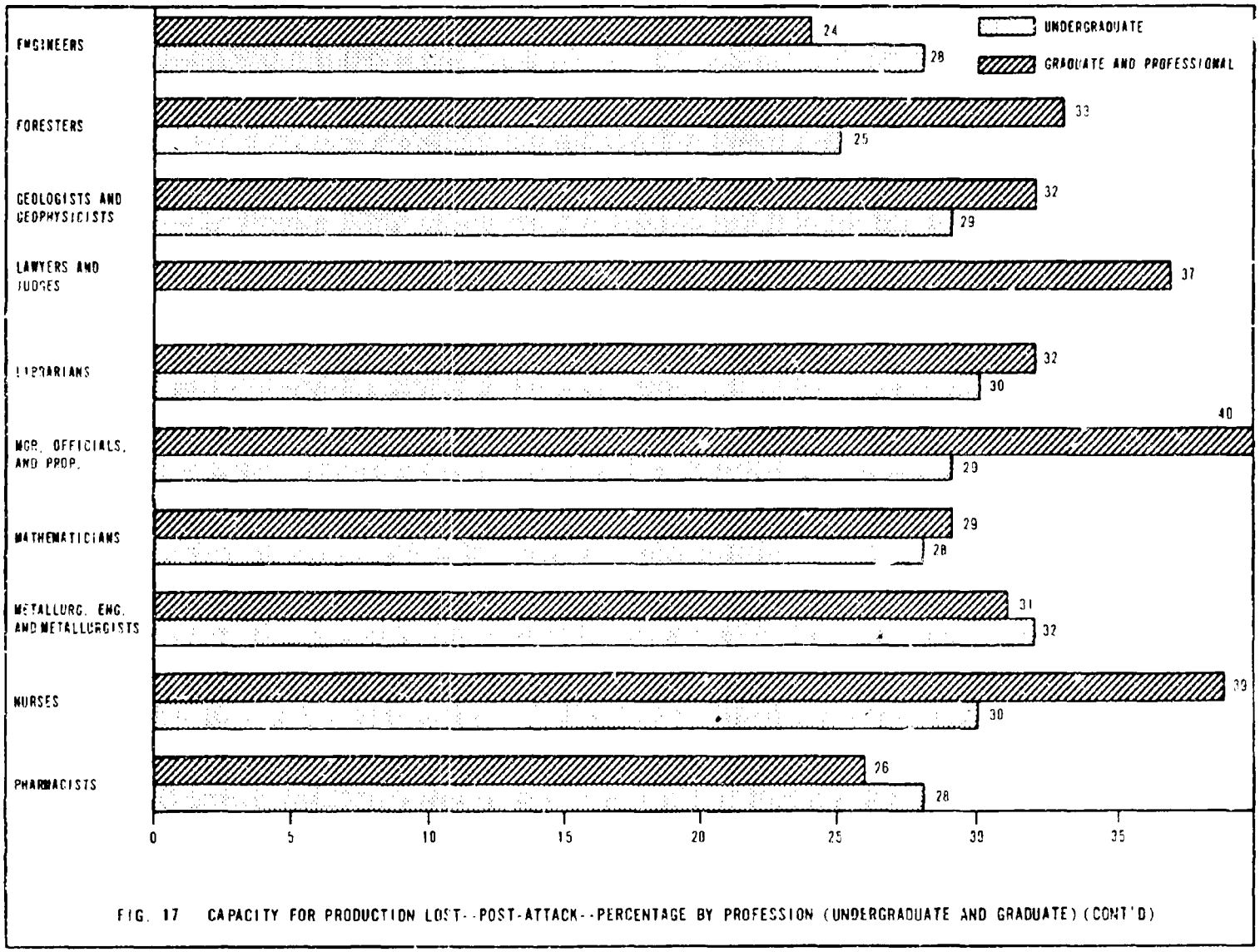

FIG. 17 CAPACITY FOR PRODUCTION LOST--POST-ATTACK--PERCENTAGE BY PROFESSION (UNDERGRADUATE AND GRADUATE) (CONT'D)

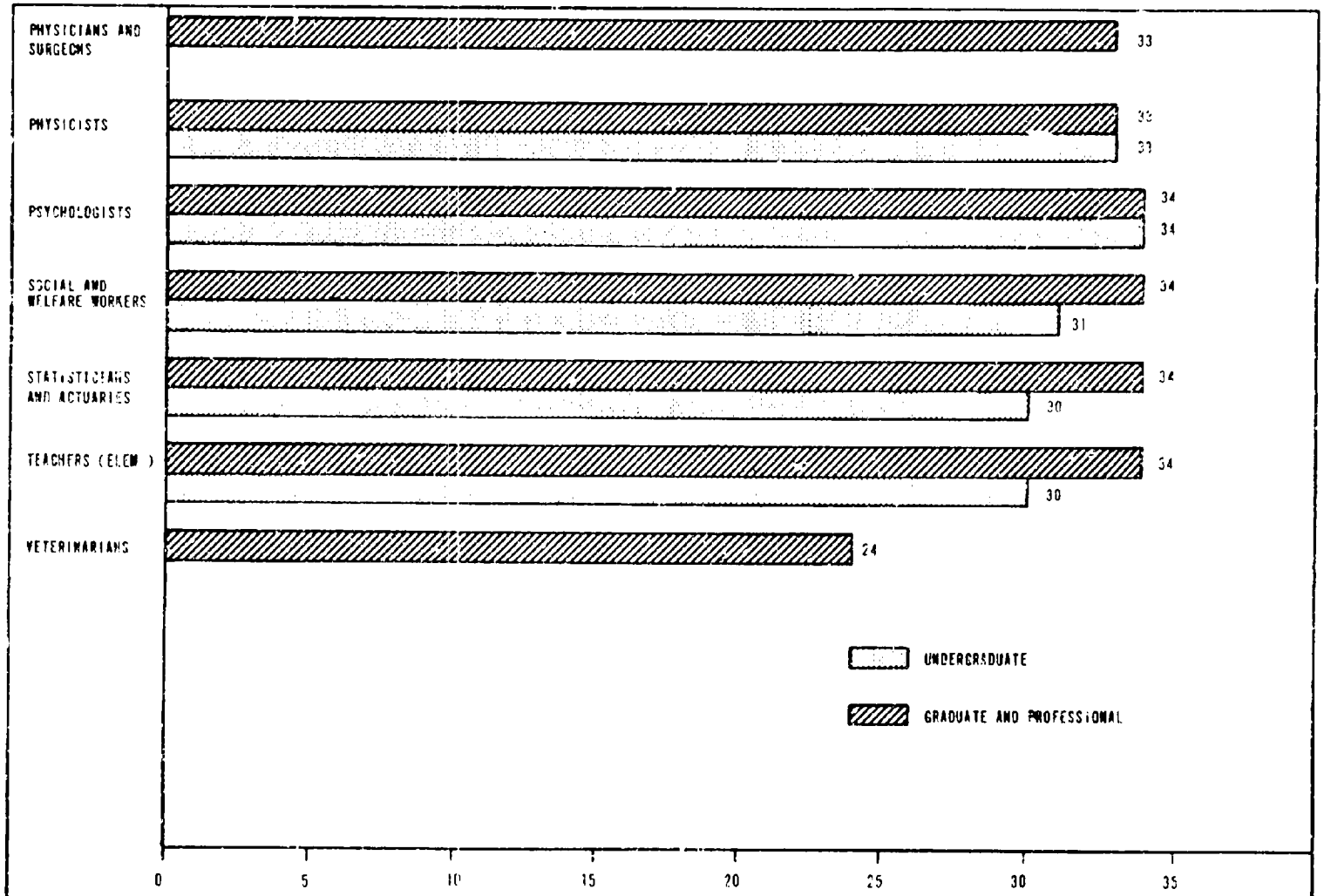

FIG. 17 CAPACITY FOR PRODUCTION LOST--POST-ATTACK--PERCENTAGE BY PROFESSION (UNDERGRADUATE AND GRADUATE) (CONT'D)

destroyed only twelve schools in the "G" size category (enrollment of 20,000 and above) as opposed to 59 schools of the "B" category (enrollment of 500 to 1000.) The twelve "G" schools, however, constituted a loss of 377,000 student units of capacity, while the "B" schools constituted a loss of only 43,200 units. The implications of this disparity are obvious when the characteristics of large schools are considered. Thus, the nature and location of "multiversities" requires consideration with respect to the study of elasticity and the specification of countermeasures.

Figures 13, 14, and 15 provide a type of profile of post-attack capability in comparison to pre-attack. The shaded areas of Figure 14 indicate the total losses as they are distributed throughout the different school size categories. Figure 15 shows both the pre- and post-attack capabilities equated to 100%. It is apparent in Figure 15 that the post-attack system will be more dependent upon the small and intermediate size schools in terms of their contribution to the nation's total higher education capability. These schools will be required to assume more of the total load. The fact that large universities are more dependent upon government appropriations for their funding suggests that an even greater burden may be placed on the smaller schools since government dollars may not be available for education after nuclear attack.

The overall results of the nationwide damage assessment appear to lend strong support to most of the assertions of the initial analysis (Chapter 3) with respect to vulnerabilities. They do not, however, fully support the contention that specific curricula will receive greater losses than others across the system. Figure 17 indicates that all curricula included in the assessment seemed to fare about equal amounts of damage. These results are somewhat puzzling in view of the fact that different states fared considerably worse than others with respect to capacity for production losses (Figure 16.) Study Phase I, it will be recalled, indicated that individual states produce disproportionate amounts of graduates in specific professions, and one would expect on the basis of this that certain curricula would receive greater losses than others when the damage to the system varied considerably by state. If the Five City attack pattern is a probable representation of a real attack pattern, then the concentration of curricula in certain states probably does not present a problem. If attack patterns vary, however, the vulnerability of specific curricula should not be discredited on the basis of this damage assessment.

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CHAPTER V. ANALYSIS OF ELASTICITY

The research presented in this chapter is directed toward assessing the impact and utility of elasticity for attack recovery. Although elasticity exists as a function of the total structure of the higher education system, its specific explication requires the study of individual education facilities. After specifying a state of system damage, it is necessary to examine a representative sample of schools to determine the nature of elasticity factors within the schools and how they may be exploited to increase production capability. In addition to supplying an attack pattern for assessing system damage, the Five City Study provided a sufficient and acceptable sample of specific schools for the direct study of elasticity factors. The higher education facilities located in the five cities represent a broad range of size categories and curriculum structures to the extent that principles for exploiting elasticity, derived from this study, should be in large part generalizable to the nationwide system. The analysis of the microcosm system in the five cities thus indicates the effect of elasticity in terms of recovery for the national system as well as for the schools within the five cities.

A. GENERAL APPROACH--HIGHER EDUCATION AND THE FIVE CITY STUDY

Eighteen accredited colleges and universities in the cities of Albuquerque, Detroit, New Orleans, Providence, and San Jose were studied to determine the nature and magnitude of damage each received from the same hypothetical attack used in the nationwide assessment. Damage was assessed in greater detail for these schools, however, to obtain information bearing on the schools' potential for recovery. While the general procedure for determining damage to the physical plant was essentially the same as that used in the nationwide analysis, personnel and faculty mortalities and injuries were calculated as factors removed from total physical damage. The data concerning general populace mortalities and injuries were supplied by the Five City Planning Group, OCD.

This assessment of damage incurred by the schools in each of the five cities in the present study achieves a certain integration with the overall Five City Study program--to the extent that much of the data presented in this chapter is a direct contribution to that program. The higher education analysis departs in some respects, however, from the policies of the Five City Program. These departures were necessary due to the complex nature of the higher education system and the specific goals of this study.

The resident population of a city derives benefits and services from a complex of social and physical systems. Frequently cited examples of these service systems are electrical power, water, sewage disposal, etc. One of the primary goals of the Five City Study is to determine, in the greatest detail possible, the ways these systems may be damaged or disrupted, and the effect of this disruption on the health and well-being of the cities' populations. Certainly if a group of buildings housing the water purification and pumping equipment for a particular city were destroyed, the water system serving the residents of that city would be grievously damaged and the effect of that damage would be felt almost immediately by the city's entire surviving population. The impact of damage to other systems serving these same residents, however, may not be so readily discernible. A similar group of buildings housing a college or university may suffer equal destruction and yet higher education service available to the residents of that city may be relatively unaffected. By the same token, it is theoretically possible that the higher education facilities located in a particular city could emerge physically untouched by the destruction of a nuclear attack and yet in terms of ability to serve the surviving residents of that city, the higher education system could be nearly totally destroyed. The residents of a particular city may attend colleges or universities quite distant from their place of residence. Thus, direct implications cannot be drawn with respect to the effect the loss of a local school would have on the residents of a particular city. Certain implications are possible, however, with respect to the effects of damage to the nationwide higher education system, and these are discussed later in the chapter.

B. GENERAL RESULTS ACROSS ALL FIVE CITIES

This section presents results calculated by viewing all schools together as one sample, irrespective of cities. Sections C through G discuss each city separately. Section H will return again to a more collective discussion and overview.

Tables 10 through 13 summarize the data representing all schools and faculty with respect to distributions and losses. General results of the damage analysis indicate that the higher education facilities within the five cities suffered considerably greater damage proportionally than those of the nation as a whole.

TABLE 10 ACCREDITED AND NONACCREDITED SCHOOL DAMAGE ACROSS FIVE CITIES

TOTAL FACULTY 7,454

TOTAL STUDENTS 102,294

DISTRIBUTION	TOTAL	A	B	C	D	E	F	G
TOTAL	31	8	6	2	8	3	2	1
NO. DESTROYED	14	4	4	0	4	1	0	1
NO. DAMAGED	4	0	1	1	0	1	1	0
NO. REMAINING	13	5	1	1	4	1	1	0

SCHOOLS:	% DESTROYED	45%	CAPACITY FOR PRODUCTION:	% DESTROYED	52%
	% DAMAGED	13%		% REMAINING	48%
	% REMAINING	42%		# DESTROYED	53,044
				# REMAINING	49,250

FACULTY:	# MORTALITIES	2301
	# INJURED	1047
	# UNINJURED	4106
	% MORTALITIES	30.8%
	% INJURED	14%
	% UNINJURED	55.2%

TABLE II FACULTY DISTRIBUTION BY SCHOOL AND CURRICULUM

	ST. MARY'S DOM. C.	U. OF ALBUQUERQUE	R.I. SCH. OF DESIGN	XAVIER UNIV.	DILLARD UNIV.	MERCY C.	MARYGROVE C.	R.I. COLLEGE	PROVIDENCE C.	BROWN UNIV.	LOYOLA UNIV.	DETROIT INST. TECH.	TULANE UNIV.	NEWCOMB C.	U. OF NEW MEXICO	U. OF DETROIT	SAN JOSE ST. C.	WAYNE ST. U.		TOTAL
ARCHITECTURE			12										19							31
ART	2	2	22	3	2	2	5	4		10			1	12	44	1	40	22		172
BIOLOGY	2	3		5	2	4	4	7	8	18	6	3	28	8	10	8	55	26		197
BUS. AD.	5	4		5	2		3		8		22	43	56		14	37	72	44		314
CHEMISTRY	3	2		5	3	5	4	2	10	18	6	3	32	5	9	14	54	25		180
DENTISTRY											36					93				129
ECONOMICS		1		2	2		3		6	11			1		7		14	26		73
EDUCATION	5	6	4	10	15	10	8	9	8	4	8		5	4	53	49	109	226		533
ENGINEERING		1								35		17	47		54	47	83	90		374
ENGLISH	6	8		8	8	17	20	22	18	40	16	14	48	15	44	43	114	121		556
HIST. AND POL. SCI.		5		5	4	3	6	12	16	26	7	5	36	8	18	17	55	47		271
HOME ECONOMICS	4					5	5											12		26
LANGUAGE	8	4		4	3	5	14	9	24	43	8	2	58	15	25	15	27	55		319
LAW											22		26		9	24		31		112
MATHEMATICS	3	3			3	2	4	10	9	41	5	5	56	4	40	26	38	33		282
MED. TECH.						8					5									13
MEDICINE													686					81		767
MORTUARY SCI.																		6		6
MUSIC	1	3		10	2	3	7	3		9	24		4	11		2	30	13		122
NURSING					13	13									9			40		75
PHARMACY				7							9				5			15		36
PHI. AND THEO.	5	4		6	5	12	23	2	31	18	12	1	8	4	5	29	16	8		189
PHYS. ED.	1	3		3		2	1	9	10			3	14	5				34		85
PHYSICS	1	2		1	2	1	4	2	7	25	6	2	17	3	9	8	16	16		122
PSYCHOLOGY		2				2	3	6		17	4	2	19	6	8	13	47	21		150
SOC. SCI.	4	2		2	3	3	5	2	5	14	3	3	64	4	10	6	21	58		209

TABLE 12 ACCREDITED SCHOOLS ONLY -- TOTAL FACULTY MORTALITIES AND INJURIES BY CURRICULUM

	TOTAL	# LOST	# INJUR'D	# REMAINING	% LOST	% INJURED	% REMAINING
ARCHITECTURE	31	15	1	15	48.3	3.3	48.3
ART	172	31	32	108	18	18.7	63.3
BIOLOGY	187	52	29	116	28.3	15.7	58.8
BUS. ADMIN.	314	97	55	162	30.8	17.5	51.5
CHEMISTRY	180	55	26	99	30.5	14.4	55
DENTISTRY	129	45	25	59	34.8	19.3	45.7
ECONOMICS	73	11	12	50	15.1	16.4	68.5
EDUCATION	533	101	111	321	18.9	20.8	60.2
ENGINEERING	374	76	74	224	20.4	19.7	59.8
ENGLISH	566	132	97	337	23.3	17.1	59.5
HIS. & POL. SCI.	271	68	40	163	25.1	14.7	60.1
HOME ECONOMICS	26	7	5	14	26.9	19.2	53.8
LANG. (CLASS. & MOD.)	319	100	43	176	31.3	13.3	13.4
LAW	112	50	19	43	44.6	16.9	38.3
MATHEMATICS	282	80	44	158	28.3	15.6	56.1
MED. TECH.	13	5	2	6	28.4	15.3	46.1
MEDICINE	767	572	68	127	74.6	8.9	16.5
MORTUARY SCI.	6	1	1	4	16.6	16.6	6..6
MUSIC	122	47	16	53	38.4	13.1	4[illegible].3
NURSING	75	22	16	37	29.3	21.3	49.3
PHARMACY	36	17	6	13	47.2	16.6	36.1
PHIL. & THEO.	189	47	26	11[illegible]	24.8	13.7	61.3
PHYS. ED.	85	27	12	46	31.7	14.1	54.1
PHYSIC	122	31	16	75	25.4	13.1	61.4
PSYCHOLOGY	150	33	23	94	22.0	15.3	62.6
SOC. SCI.	209	80	31	93	38.2	14.8	46.9

TABLE 13 FACULTY MORTALITIES AND INJURIES BY CURRICULUM AND CITY -- ACCREDITED SCHOOLS ONLY

	ALBUQUERQUE				DETROIT				NEW ORLEANS				PROVIDENCE				SAN JOSE			
	TOT.	M	I	UI	TOT.	M	I	UI	TOT.	M	I	UI	TOT.	M	I	UI	TOT.	M	I	UI
ARCHITECTURE	0	0	0	0	0	0	0	0	19	15	1	3	12	0	0	12	0	0	0	0
ART	46	10	17	19	30	5	7	18	20	16	1	3	36	0	0	36	40	0	7	33
BIOLOGY	13	3	5	5	45	8	10	27	51	41	4	6	33	0	0	33	55	0	10	45
BUS. ADMIN.	18	4	6	8	127	22	30	75	88	71	6	11	9	0	0	9	72	0	13	59
CHEMISTRY	11	2	4	5	51	9	12	30	54	44	4	6	30	0	0	30	34	0	6	28
DENTISTRY	0	0	0	0	93	16	22	55	36	29	3	4	0	0	0	0	0	0	0	0
ECONOMICS	8	2	3	3	29	5	7	17	5	4	0	1	17	0	0	17	14	0	2	12
EDUCATION	59	13	21	25	293	50	68	175	47	38	3	6	26	0	0	26	109	0	19	90
ENGINEERING	55	12	20	23	154	26	36	92	47	38	3	6	35	0	0	35	83	0	15	68
ENGLISH	52	12	19	21	219	38	51	130	101	82	7	12	80	0	0	80	114	0	20	94
HIS. & POL. SCI.	23	5	8	10	79	14	18	47	60	49	4	7	54	0	0	54	55	0	10	45
HOME ECONOMICS	0	0	0	0	22	4	5	13	4	3	0	1	0	0	0	0	0	0	0	0
LANGUAGES	29	6	10	13	91	16	21	54	96	78	7	11	76	0	0	76	27	0	5	22
LAW	9	2	3	4	55	9	13	33	48	39	3	6	0	0	0	0	0	0	0	0
MATHEMATICS	43	10	16	17	70	12	16	42	71	58	5	8	60	0	0	60	38	0	7	31
MED. TECH.	0	0	0	0	8	1	2	5	5	4	0	1	0	0	0	0	0	0	0	0
MEDICINE	0	0	0	0	81	14	19	48	686	558	49	79	0	0	0	0	0	0	0	0
MORTUARY SCI.	0	0	0	0	6	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0
MUSIC	3	1	1	1	25	4	6	15	54	44	4	6	12	0	0	12	30	0	5	25
NURSING	9	2	3	4	53	9	12	32	13	11	1	1	0	0	0	0	0	0	0	0
PHARMACY	5	1	2	2	15	3	3	9	15	13	1	2	0	0	0	0	0	0	0	0
PHIL. & THEO.	9	2	3	4	73	13	17	43	40	32	3	5	51	0	0	51	16	0	3	13
PHYS. ED.	3	1	1	1	40	7	9	24	23	19	2	2	19	0	0	19	0	0	0	0
PHYSICS	11	2	4	5	31	5	7	19	30	24	2	4	34	0	0	34	16	0	3	13
PSYCHOLOGY	10	2	4	4	41	7	9	25	29	24	2	3	23	0	0	23	47	0	8	39
SOC. SCI.	12	2	4	6	75	13	17	45	80	65	6	9	21	0	0	21	21	0	4	17

Nationwide damage calculations indicated a total loss in higher education capacity for production of 31% while the loss within the five cities was found to be over 52% (Table 10.) The faculty losses for all schools combined was 30.8% of the original total (Table 10.) This is somewhat lower than would be expected in view of the capacity for production losses, but can probably be explained due to the fact that the schools suffering the least damage were the size "A" schools (enrollments of 500 and below) and these schools are characterized by an extremely high faculty/student ratio. Study Phase I indicated, for example, that the average faculty/student ratio for size "A" schools is .13 or approximately one faculty member for every eight students. The second highest ratio occurred in the case of the size "B" schools which had one faculty member for every thirteen students. Faculty thus constitute an important element of elasticity since they may be brought together to increase the capability of remaining schools.

It should be noted that Table 10 indicates a total of 31 schools summarized while most other tables present data for only eighteen basic schools. The 31 schools totaled in Table 10 include 13 nonaccredited colleges and junior colleges which were not considered elsewhere because they do not have four-year baccalaureat programs and thus do not fully qualify as higher education facilities as defined in this study. They do, however, have important implications for elasticity and thus were included for consideration in this section. The capacity for production losses for accredited schools only, exceeds 67%. It is not clear exactly why the junior colleges lowered the total damage, but the fact that they did indicates that they may share many of the elastic properties of the size "A" schools and their physical facilities and instructors may be of considerable value for reinstating post-attack capability.

Table 11 indicates the distribution of faculty across the eighteen accredited schools by size of school and curriculum. The important consideration to note in this table is that while the large schools have characteristically large departments over a wide range of curricula, the smaller schools do have at least one or two faculty members in most of the basic curricula thus indicating potential capability should they be brought together under a single department. The smaller schools are sadly lacking, however, in the fields of law, engineering, and medicine.

Table 12 provides faculty mortality and injury estimates by curricula. The effect of vulnerabilities in specific curricula is strongly illustrated here by the losses in the field of medicine. The capability for training medical doctors has been nearly obliterated within the sample, and the only apparent elastic property is the fact that some faculty members remain. Table 13 indicates that the losses in the field of medicine were solely due to high personnel losses in the cities of Detroit and New Orleans.

C. ALBUQUERQUE

Tables 14 and 15 summarize the data concerning the schools in Albuquerque. Table 14 describes the characteristics of the two education facilities located in that city--The University of Albuquerque (formerly The College of St. Joseph on the Rio Grande) and The University of New Mexico. Table 15 shows that the larger of the two schools (University of New Mexico) received the greatest damage to the physical facility. Uninjured faculty members in this case could conceivably teach at the University of Albuquerque, but the facilities there would not be adequate to support even a majority of the potential faculty and students available.

D. DETROIT

The corresponding data for the colleges and universities of Detroit are presented in Tables 16 and 17. These data indicate that Detroit's five accredited and two unaccredited schools suffered considerable damage. Faculty, on the other hand, fared much better with total losses of only 14%. The greatest single loss occurred with Wayne State University. This "G" school had a wide variety of curricula as well as most of the other attributes characteristic of "G" schools. With respect to recovery, it would seem reasonable to attempt immediate repair and rebuilding efforts on the University of Detroit to permit rapid capability restoration for curricula such as engineering and business administration.

E. NEW ORLEANS

The damage to the higher education facilities of New Orleans presents an almost impossible problem in terms of restoration. Tables 18 and 19 illustrate the data collected on these facilities. As Table 19 indicates, all schools within

TABLE 14 ALBUQUERQUE

DESCRIPTORS	U. OF ALBUQUERQUE	U. OF NEW MEXICO
ENROLLMENT	435	8,842
UNDERGRAD.	426	6,998
GRAD.	9	1 844
SIZE OF CATEGORY[1]	A	
% INSTATE (UNDERGRAD.)	77%	83%
TOTAL FACULTY	48	347
Ph.D.	10	169
M.S. A.	34	150
B.S. A.	4	25
LIBRARY VOLUMES	53,000	382,315
NO. OF DEPT'S.	12	22
CURRICULA STRUCTURE	LIB. ARTS & SCIENCES, BUS. AD., EDUCATION	LIB. ARTS & SCIENCES, BUS. AD., EDUCATION, ENGINEERING, LAW, NURSING, PHARMACY
TYPE[2]	E	U
LEVEL[3]	III	IV
1963 DEGREES CONF.	43	1,007
B.A. S.	45	688
M.A. S	0	292
Ph.D.	0	27
TOTAL CURRENT INCOME	537,217	13,323,300
GOV'T. APPROPRIATIONS		4,847,440
CONTRACT RESEARCH		1,730,200
$ VALUE OF PHYS. PLANT	2,552,800	26,900,000
CAP. OF RES. HALLS	215	1 887

TABLE 15 ESTIMATED DAMAGES TO COLLEGES AND UNIVERSITIES, ALBUQUERQUE, NEW MEXICO

FACILITIES

SCHOOL	SIZE CLASS	PSI	DAMAGE	CAPACITY FOR PRODUCTION			
				ORIGINAL	LOST	REMAINING	% REMAINING
UNIV. OF ALBUQUERQUE	A	2.5	SLIGHT	435	0	435	100
UNIV. OF NEW MEXICO	E	6.0	MODERATE	8642	4321	4321	50

PERSONNEL

	GENERAL POPULACE	FACULTY
TOTAL	390,000	395
MORTALITIES	85,900	89
% OF TOTAL	22.6	22.5
INJURIES	138,200	143
% OF TOTAL	36.3	36.9
UNINJURED	155,900	163
% OF TOTAL	41.1	41.5

TABLE 16 DETROIT

DESCRIPTORS	DETROIT INST. TECH.	MARYGROVE C.	MERCY C.	U. OF DETROIT	WAYNE STATE U.
ENROLLMENT	2,330	1,154	859	10,345	20,836
UNDERGRAD.	2,330	1,154	859	9,047	14,626
GRAD.				1,297	5,369
SIZE CATEGORY[1]	D	C	B	F	G
% IN-STATE (UNDERGRAD)	95%		94%	82%	98%
TOTAL FACULTY	110	108	97	614	1,113
Ph.D.	8	28	20	114	433
M.A./S.	57	66	62	394	370
B.A./S.	4	16	15	20	32
LIBRARY VOLUMES	30,000	102,945	36,477	245,000	833,750
NO. OF DEPT'S.	13	14	14	25	38
CURRICULA STRUCTURE	LIB. ARTS, BUS. AD., ENGINEERING	LIB. ARTS AND SCIENCES, EDUCATION	LIB. ARTS AND SCIENCES, NURSING	LIB.ARTS, AND SCIENCES, BUS. AD., LAW, DENTISTRY, EDUCATION, ENGINEERING	LIB. ARTS AND SCIENCES, EDUCATION, ENGINEERING, MEDICINE, NURSING, PHARMACY, LAW, BUS. AD., MORTUARY SCIENCE.
TYPE[2]	J	E	E	K	K
LEVEL[3]	II	II	II	III	III
1963 DEGREES CONF.	189	222	115	1,283	3,491
B.A./S.	189	222	115	844	2,201
M.A./S.				439	1,201
Ph.D.					89
TOTAL CURRENT INC.	1,291,137	1,540,888	959,407	7,812,000	32,591,530
GOV'T. APPROP.					22,191,139
CONTRACT RES.				136,000	1,251,110
$ VALUE OF PHY. PLANT	1,220,458	9,615,584	4,822,359	18,513,804	61,305,457
CAPACITY OF RES. HALLS		415	250	920	442

TABLE 17 ESTIMATED DAMAGES TO COLLEGES AND UNIVERSITIES, DETROIT, MICHIGAN

FACILITIES

SCHOOL	SIZE CLASS.	PSI	DAMAGE	CAPACITY FOR PRODUCTION			
				ORIGINAL	LOST	REMAINING	% REMAINING
DETROIT INST. OF TECH.	D	15	SEVERE	2,330	2,330	0	0
DUNS SCOTUS C.	A	3	SLIGHT	61	0	61	100
HIGHLAND PARK JR. C.	D	8	SEVERE	2 077	2,077	0	0
MARYGROVE C.	C	8	MODERATE	1,154	577	577	50
MERCY C.	B	5	MODERATE	859	429	429	50
U. OF DETROIT	F	6	MODERATE	10,345	5,172	5,172	50
WAYNE ST. MED. SCH.	A	15	SEVERE	451	451	0	0
WAYNE ST. U.	G	15	SEVERE	20,836	20,836	0	0

PERSONNEL

	GENERAL POPULACE	FACULTY
TOTAL	2,833,000	2,126
MORTALITIES	489,560	366
% OF TOTAL	17.2	14.4
INJURIES	662,250	495
% OF TOTAL	23.3	23.3
UNINJURED	1,681,190	1,265
% OF TOTAL	59.3	59.5

TABLE 18 NEW ORLEANS

DESCRIPTORS	DILLARD U.	LOYOLA U.	NOTRE DAME SEM.
ENROLLMENT	882	2,718	138
UNDERGRAD.	882	2,475	72
GRAD.		243	66
SIZE CATEGORY[1]	B	D	A
% INSTATE	65%	82%	93%
TOTAL FACULTY	69	247	9
Ph.D.	20	35	3
M.S./A.	45	150	6
B.S./A.	4	22	
LIBRARY VOLUMES	62,725	202,869	41,687
NO. OF DEPT'S.	8	14	2
CURRICULA STRUCTURE	LIB. ARTS AND SCIENCES, BUS. AD., EDUCATION, NURSING	LIB. ARTS AND SCIENCES, BUS. AD., PHARMACY, LAW, DENTISTRY, EDUCATION	LIBERAL ARTS
TYPE[2]	E	K	G
LEVEL[3]	II	III	III
1983 DEGREES CONF.	121	383	27
B.A./S.	121	227	23
M.A./S.		156	4
Ph.D.			
TOTAL CURRENT INC.	1,248,270	1,225,5[illegible]	
GOV'T. APPROP.		116,230	
CONTRACT RES.			
$ VALUE OF PHY. PLANT	6,479,772	8,562,672	
CAP. OF RES. HALLS.	450	632	175

TABLE 18 NEW ORLEANS (CONT'D)

DESCRIPTORS	ST. MARY'S DOM. C.	TULANE U.	XAVIER U.
ENROLLMENT	449	7,109	800
UNDERGRAD.	449	4,870	691
GRAD.		2,239	43
SIZE OF CATEGORY[1]	A	E	B
% INSTATE	75%	30%	73%
TOTAL FACULTY	50	1,404	75
Ph.D.	11	323	22
M.S./A.	29	872	46
B.S./A.	10	204	7
LIBRARY VOLUMES	42,000	841,026	88,760
NO. OF DEPTS.	3	26	10
CURRICULA STRUCTURE	LIB. ARTS AND SCIENCES, EDUCATION	LIB. ARTS AND SCIENCES, BUS. AD., ENG., LAW, MEDICINE	LIB. ARTS AND SCIENCES, EDUCATION, PHARMACY
TYPE[2]	E	K	I
LEVEL[3]	II	IV	III
1983 DEGREES CONF.	68	1,128	136
B.A./S.	68	586	115
M.A./S.		447	21
Ph.D.		95	
TOTAL CURRENT INC.	811,682	21,872,916	1,056,357
GOV'T. APPROP.			
CONTRACT RES.		3,745,739	
$ VALUE OF PHYS. PLANT	2,319,981	43,826,441	3,892,783
CAPACITY OF RES. HALLS	172	2,899	268

TABLE 15 ESTIMATED DAMAGES TO COLLEGES AND UNIVERSITIES, NEW ORLEANS, LOUISIANA

FACILITIES

SCHOOL	SIZE CLASS.	PSI	DAMAGE	CAPACITY FOR PRODUCTION			
				ORIGINAL	LOST	REMAINING	% REMAINING
DILLARD U.	B	20	SEVERE	882	882	0	0
LA. ST. U. AT NEW ORLEANS	D	5	SEVERE*	3,110	3,110	0	0
LA. ST. U. MED. SCH.	A	100	SEVERE	482	482	0	0
LOYOLA U.	D	10	SEVERE	2,718	2,718	0	0
OUR LADY OF HOLY CROSS C.	A	5	SEVERE*	52	52	0	0
ST. MARY'S DOM. C.	B	10	SEVERE	503	503	0	0
SOULE C.	B	50	SEVERE	700	700	0	0
TULANE MED. SCH.	A	100	SEVERE	495	495	0	0
TULANE U.	E	10	SEVERE	7,109	7,109	0	0
XAVIER U.	B	20	SEVERE	800	800	0	0

*DUE TO FLOODING

PERSONNEL

	GENERAL POPULACE	FACULTY
TOTAL	985,600	2,270
MORTALITIES	801,052	1,846
% OF TOTAL	81.3	81.3
INJURIES	71,143	163
% OF TOTAL	7.2	7.2
UNINJURED	113,405	261
% OF TOTAL	11.5	11.5

the bounds of the city are severely damaged. The only potential for reinstating any capability at all would be in the Louisiana State University at New Orleans and Our Lady of Holy Cross College, where buildings may still be standing after flooding recedes. Even there, capability would be extremely doubtful. To add to the problem, 81% of the faculty in New Orleans were fatalities.

F. PROVIDENCE

Data for Providence is summarized in Tables 20 and 21. The higher education damage in this city presents a completely opposite picture in contrast to New Orleans. Damage will primarily be of the nature of glass breakage and easily repairable.

The schools in Providence have a high potential for relieving the national system in view of their slight damage and operating characteristics. Brown University, for example, has an unusually high percentage of faculty with a ratio of one faculty member for every five students. Thus, many more students could conceivably be added without requiring additional faculty. Other characteristics which make this university highly elastic include a very large library (1,211,378 volumes), a broad curricula structure (30 departments), a fairly large graduate school, a high total income with no dependency upon government appropriations, a sizable capability for contract research, and a high physical plant value. (Table 20.)

G. SAN JOSE

Data for the higher education facilities in San Jose is presented in Tables 22 and 23. The situation here is much the same as that in Providence. Less elasticity is available in San Jose, however, due to the characteristics of San Jose State College as compared with Brown University. San Jose State College has one faculty member for every eighteen students (about average), and although it has a greater enrollment than Brown, it has considerably less library volumes and departments. The total current income is only slightly less than Brown, with a significant dependency upon government appropriations.

H. OVERVIEW

The data cited in Chapter 4 indicated that individual curricula did not suffer disproportionate damage and thus the schools in the five cities should not be

TABLE 20 PROVIDENCE

DESCRIPTORS	BROWN U.	PROVIDENCE C.	RHODE IS. C.	RHODE IS. SCH. OF DES.
ENROLLMENT	4,283	2,406	2,717	911
UNDERGRAD.	3,333	2,392	1,661	885
GRAD.	950	14	1,056	26
SIZE OF CATEGORY[1]	D	D	D	B
% OF INSTATE (UNDERGRAD.)	15%	60%	96%	16%
TOTAL FACULTY	804	159	115	93
Ph.D.	340	46	48	8
M.S./A.	176	86	65	51
B.S./A.	275	27	2	15
LIBRARY VOLUMES	1,211,378	58,473	42,545	33,041
NO. OF DEPT'S.	30	15	14	6
CURRICULA STRUCTURE	SCIENCE AND LIB. ARTS, ENGINEERING BUS. AD., EDUCATION, M.S. IN MED. SCIENCE	LIB. ARTS AND SCIENCES, BUS. AD., EDUCATION	EDUCATION	ART EDUCATION, COMMERCIAL AND FINE ARTS
TYPE[2]	E	E	D	H
LEVEL[3]	IV	III	III	III
1983 DEGREES CONF.	898	428	349	157
B.A./S.	673	424	257	132
M.S./S.	161	4	92	35
Ph.D.	64			
TOTAL CURRENT INC.	18,692,000	3,797,386	2,467,672	2,182,865
GOV'T. APPROP.		228,284	1,760,539	
CONTRACT RES.	2,141,000			
$ VALUE OF PHYS. P.	40,000,000	15,092,928	7,973,584	6,900,000
CAP. OF RES. HALLS	2,900	850	144	360

TABLE 21 ESTIMATED DAMAGES TO COLLEGES AND UNIVERSITIES, PROVIDENCE, RHODE ISLAND

FACILITIES

SCHOOL	SIZE CLASS.	PSI	DAMAGE	CAPACITY FOR PRODUCTION			
				ORIGINAL	LOST	REMAINING	% REMAINING
BROWN U.	D	.5 - .3	SLIGHT	4,283	0	4,283	100
BRYANT C.	C	.5 - .3	SLIGHT	1,492	0	1,492	100
CATHOLIC TCHRS. C.	A	.5 - .3	SLIGHT	250	0	250	100
PEMBROKE		.5 - .3	SLIGHT				
PROVIDENCE C.	D	.5 - .3	SLIGHT	2,406	0	2,406	100
R. I. C. OF EDUC.	B	.5 - .3	SLIGHT	2,787	0	2,787	100
R. I. SCH. OF DESIGN	B	.5 - .3	SLIGHT	911	0	911	100
ROGER WILLIAMS JR. C.	A	.5 - .3	SLIGHT	309	0	309	100

PERSONNEL

NO INJURIES OR LOSSES

TABLE 22 SAN JOSE

DESCRIPTORS	SAN JOSE ST. COL.
ENROLLMENT	17,137
UNDERGRAD.	14,377
GRAD.	2,760
SIZE CATEGORY[1]	F
% INSTATE (UNDERGRAD.)	95%
TOTAL FACULTY	966
Ph.D.	493
M.S./A. OR PROF.	399
B.S./A.	76
LIBRARY VOLUMES	250,000
NO. OF DEPT'S.	22
CURRICULA STRUCTURE	LIB. ARTS AND SCIENCES BUSINESS ADVERTISING EDUCATION ENGINEERING, APPLIED ARTS AND PROFESSIONS
TYPE[2]	I
LEVEL[3]	III
1983 DEGREES CONF.	2,778
B.S./A.	2,421
M.A./S.	357
Ph.D.	0
TOTAL CURRENT INCOME	20,487,117
GOV'T. APPROPRIATIONS	12,953,770
CONTRACT RESEARCH	274,387
$ VALUE OF PHYS. PLANT	50,828,704
CAP. OF RES. HALLS	1,508

TABLE 23 ESTIMATED DAMAGES TO COLLEGES AND UNIVERSITIES, SAN JOSE, CALIFORNIA

FACILITIES

SCHOOL	SIZE CLASS.	PSI	DAMAGE	CAPACITY FOR PRODUCTION			
				ORIGINAL	LOST	REMAINING	% REMAINING
SAN JOSE BIBLE C.	A	1.75	SLIGHT	118	0	118	100
SAN JOSE CITY C.	D	2.5	SLIGHT	2,970	0	2,970	100
SAN JOSE JR. C.		2.0	SLIGHT				
SAN JOSE ST. C.	F	2.0	SLIGHT	966	0	966	100
U. OF SANTA CLARA	E	3.0	SLIGHT	288	0	288	100

PERSONNEL

	GENERAL POPULACE	FACULTY
TOTAL	300,000	1390
MORTALITIES	0	0
% OF TOTAL	0	0
INJURIES	53,000	246
% OF TOTAL	17.7	17.7
UNINJURED	247,000	1144
% OF TOTAL	82.3	82.3

subjected to student loadings with respect to any single curriculum post-attack. They will, however, witness proportionately greater enrollment demands in their small and intermediate schools due to overall systems losses in large schools. Even with the adoption of effective sheltering programs, population losses are bound to be fairly high in a nuclear attack, and thus students will decrease along with higher education capability. The post-attack higher education system will require that small and intermediate schools carry a greater portion of the load than they presently do, however, regardless of what that load may be. Intermediate schools similar to Brown University would have considerable capacity for expansion, but Brown seems to be an exception rather than the rule. The elasticity factors inherent in the smaller schools, as for example the University of Albuquerque, are less spectacular, but more consistent.

Curricula such as medicine may cause problems. Although the losses within medicine are not disproportionately high across the nation, this curriculum is very difficult to absorb through elasticity. Neither the instructors nor facilities in surviving nonmedical schools appear complementary to the requirements of a medical training department.

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FOOTNOTES

1. Size Category[1]

A--0-500

B--501-1000

C--1001-2000

D--2001-5000

E--5001-10,000

F--10,001-20,000

G--20,000 up

2. Type[2]

The designation (under Type) indicates type of program offered.

B. Liberal arts and general--including those institutions offering a 4-year program leading to the bachelor's degree;

C. Liberal arts and general, and terminal-occupational ("terminal-occupational" indicates programs of less than 4-years);

D. Primarily teacher preparatory;

E. Liberal arts and general, and teacher preparatory;

F. Liberal arts and general, teacher preparatory, and terminal-occupational;

G. Professional only (not including teacher preparatory);

H. Professional and teacher preparatory;

I. Professional and terminal-occupational;

J. Liberal arts and general with 1 or 2 professional schools; and,

K. Liberal arts and general with 3 or more professional schools--including institutions organized as universities.

3. Level[3]

The following categories (under Level) designate the highest level of training offered.

II. Only the bachelor's and/or first professional degree--includes those institutions offering courses of studies leading to the customary bachelor of arts or bachelor of science degree, and all those degrees which entitle the possessor to enter the profession indicated; e.g., doctor of medicine, bachelor of pharmacy, or bachelor of science in engineering;

III. Master's and/or second professional degree--includes those institutions offering the customary first graduate degree, and any degree earned in the same field after the first professional degree, or after a bachelor's degree in that field; e.g., the degree of electrical engineer, earned after the bachelor of engineering, or the degree of doctor of science of law earned after the bachelor of laws degree;

IV. Doctor of philosophy and equivalent degrees.

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[1] King, R. B., Kleiner, A. M., and W. O. Hambacher, Higher Education and the Post-Attack Period. Contract OCD-PS-65-48, HRB-Singer, Inc., 1964, p. 14.

[2, 3] American Universities and Colleges, ed., A. M. Carter.. American Council on Education: Washington, D. C., 1964, p. 1282.

CHAPTER VI. COUNTERMEASURES

There are basically two types of countermeasures which would contribute toward the effectiveness of the post-attack higher education system. First, there are those which may be exercised pre-attack and are designed to protect or reduce damage to the system by dissipating existing vulnerability producing characteristics. Second, there are those which may be applied in the immediate post-attack to enhance the remaining system capability and hasten recovery. The latter, and at least part of the former, would be aimed primarily at the manipulation and exploitation of elasticity inherent in the system. This chapter presents some suggested countermeasures of both types for consideration and possible incorporation in civil defense programs. The countermeasures are based upon the findings of this report.

A. PRE-ATTACK COUNTERMEASURES

The most predominant vulnerability of the present higher education system is the location and operating characteristics of the system's large universities and "multiversities". A valid, but not very practical solution would be to move them, and/or break them up in some manner so it would be impossible to literally "wipe out" the capability of such valuable institutions with one bomb. There are more practical measures to be taken, however, which eventually would accomplish just that. First, don't build or create any new multiversities which would accentuate the problem. Second, if they must be built, place them in a rural setting away from likely strategic targets and metropolitan population complexes. These are admittedly "tall orders" for education planners to undertake.

A second vulnerability appears to exist with respect to specific curricula. The nature of this vulnerability is not as widespread and conclusive as asserted in Study Phase I, but it definitely appears to exist with respect to medical training facilities. The action required would be to decentralize existing medical schools now located predominately in large cities, and establish more numerous, smaller facilities associated with universities in less vulnerable locations.

A third pre-attack countermeasure, aimed at recovery rather than protection, would be the development of a set of operational guidelines designed to inform education administrators of potential disruptions which their institution and higher

education in general may experience after attack. A set of planned reinstatement procedures should also be prepared and distributed to inform administrators of the type of actions which may be necessary to reinstate capability with respect to particular schools or cirricula.

The study of elasticity in Chapter 5 suggests that small schools, although they will survive the effects of the attack, will not present as much post-attack elasticity as less numerous, intermediate schools (for example, Brown University). This is due primarily to their lack of capability in curricula such as engineering, the physical sciences, law, and other curricula found predominately in larger schools. Steps could be taken in the immediate pre-attack society to prepare these schools through program diversity and expansion within their structures. Research projects could be encouraged within the schools to enhance their capabilities in the sciences and establish their potential for assuming new, expanded roles in the event of attack.

A final recommendation with respect to pre-attack planning is to recognize and account for trends evident in today's system which will carry through to the post-attack system. There is a certain amount of appeal in the idea that the disruptive effects of nuclear destruction and the accompanying requirement for rebuilding will provide an opportunity for system changes recognized as needed but impossible to bring about in today's system.

B. POST-ATTACK COUNTERMEASURES

The first of these countermeasures aimed at the control of elasticity would be to implement a program designed to provide immediate damage assessment with respect to the higher education system. Once damage was established plans issued to university administrators pre-attack could be rapidly reevaluated and modified if necessary before implementation.

A second post-attack countermeasure of considerable benefit would be the programming and allocation of government funds to the schools which need them the most. On the basis of the results presented in this report government funding should go to:

1. undamaged small and intermediate schools possessing capabilities in the sciences and professions similar to large universities;

2. undamaged large universities.

The funding should not be used for the rebuilding of severely damaged universities regardless of their size, reputation, and once existing capability. The money will be more effectively utilized if applied to the intermediate schools to create, in them, the desirable features of the large university.

If the effect of large school destruction is pronounced government intervention will be highly desirable in organizing and implementing new education centers based around a number of smaller surviving facilities. Faculty and equipment surviving large school destruction may have to be moved to new centers, and the techniques of mass instruction (via television, for example) will have to be established in facilities not equipped nor accustomed to their operation. The necessary intervention would take the form of directives, funding, transportation, organization assistance, and overall support.

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CHAPTER VII. SUMMARY AND GENERAL CONCLUSIONS

The research presented in this report deals with the problem of insuring the effective operation of higher education as a social institution in the post-attack society. The report takes the position that social institutions in general and higher education in particular will play an important role in rebuilding the social organization and preventing cultural stagnation after thermonuclear war. Higher education will be responsible for replenishing the human resources necessary for technological growth following disruption, and its ability to perform this function will depend to a large extent upon the steps that are taken both pre- and post-attack to minimize system disruption and hasten recovery.

Phase I of the research constituted an initial investigation of the present higher education system's physical and operating characteristics to determine their susceptibility for disruption. The results of that phase indicated that the system is characterized by a number of physical properties which render it highly vulnerable to disruption from attack. First, most of the nation's higher education capability is concentrated on the east and west coastlines, and in the immediate vicinity of large metropolitan centers. Thus, many schools are likely to be damaged by the peripheral effects of bombs directed toward population centers and other targets of a strategic nature within these areas. Second, specific states and geographic sectors produce disproportionate quantities of college graduates trained in particular professions. These trained individuals are supplied to the nation as a whole, and dependencies exist between the geographic areas where the individuals are employed and the areas where they are trained. Nuclear destruction in these centers of education will thus create future skill deficits for the entire nation. A third type of vulnerability occurs with respect to the nation's largest universities. These schools are few in number, but produce many graduates. Not only do they produce vast numbers of students but they make large contributions in research and consultation to society. They have the most advanced facilities and equipment, the highest trained faculty, the broadest range of curricula. Because of their research and leadership contributions, they may constitute strategic targets in and of themselves. This is further accentuated by the fact that they are located primarily in large metropolitan areas and are thus quite likely to receive heavy damage or complete destruction even if they are not targets themselves.

The results of Phase I also called attention to what may be considered elasticity within the higher education system. A high degree of elasticity is present in the form of small and intermediate size colleges. These schools exist in large numbers and are distributed relatively evenly throughout the nation. They are characterized by aspects such as high faculty to student ratios, many library volumes per student, little dependency upon government funding, and high physical plant value per student which indicate their potential for expansion. If properly directed they will provide a cushion effect should heavy destruction occur in the large universities.

Phase II of the reported effort was designed to expand and complement these findings by (1) verifying the existence of the system vulnerabilities, and (2) clarifying the nature of system elasticity to permit its control and manipulation through countermeasures. The verification process was performed by applying a hypothetical attack pattern to the nationwide higher education system and assessing the resulting damage across geographic sectors, different types of schools, and specific curricula. Elasticity was studied by analyzing the specific damage incurred by a small sample of colleges and universities to determine ways in which the capability they provided could be reinstated. Based upon the results of that analysis, a series of countermeasures was specified to expedite the reinstatement of education capability through protection and the exploitation of elasticity.

The Five City Study provided a convenient framework for conducting Phase II of the higher education study. The first attack pattern specified for the Five City Study was utilized in the nationwide damage assessment. The results of that assessment verified the assertions of Phase I and provided data for use in the study of elasticity. The sample colleges and universities used in the elasticity analysis were those existing in the five cities of Albuquerque, Detroit, New Orleans, Providence and San Jose. Damage to the schools in these cities was assessed from the standpoint of both the physical facilities and personnel (faculty and administration.)

The results of the elasticity analysis indicated that physical facility losses will considerably exceed those with faculty and administrative personnel. This will, of course, be a virtue, since it is easier to construct buildings than to train faculty. Some degree of caution is necessary, however, with respect to assuming that post-attack education capability will thus be increased. Faculty

members may be needed for work and consultation in their respective fields during immediate recovery, and thus will not be available for teaching. This is especially likely to be true in the case of medical instructors, engineers, economists, and agriculture instructors.

Small colleges will offer a number of advantages for reinstating capability. They will be able to provide physical facilities and may be combined to form capable departments in many fields including graduate study. Their capability may be increased by adopting techniques of mass instruction (television) normally used in large universities. A disadvantage was noted, however, with respect to relying upon small colleges exclusively. The results of the elasticity analysis indicate that undamaged intermediate size schools provide greater capability in several curricula. Especially heavy losses are likely to occur with respect to curricula such as medicine, engineering and law. Losses in these fields will apply to both faculty and physical facilities due to their present relationship to large cities and other targets. Small colleges are not presently geared to adopt these curricula and thus do not offer elasticity in this respect. Intermediate schools frequently have departments in these fields and thus provide greater immediate capability for expansion.

Conclusions with respect to countermeasures hinge basically around the promotion of changes within the present higher education system, and the allocation of government funds and other forms of assistance with respect to the post-attack system. Steps should be taken in the pre-attack society to reduce the vulnerability of the nation's large schools through decentralization and the avoidance of cities and strategic targets. Small colleges should be notified of the role they may be expected to play in the post-attack system, and steps should be taken to prepare them for assuming that role. Graduate schools should be instated and greater emphasis placed upon technical and scientific curricula. Plans for the allocation of government funding should be prepared in the pre-attack system and placed in effect as soon as possible post-attack. The plans should place emphasis upon the expansion of small and intermediate schools and avoid wasting money and effort on the rebuilding of seriously damaged large universities. The most efficient procedure will be to make the intermediate schools of today into the large universities of tomorrow.

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13. ABSTRACT

This report presents an investigation into the post-attack capability of the institution of higher education. The existing higher education system was described in terms of physical and organizational characteristics which render it vulnerable to disruption from nuclear attack. The vulnerabilities were verified by assessing system damage resulting from a hypothetical attack. Operational elasticity inherent in the system was clarified with respect to the post-attack capability of a sample of schools, and countermeasures designed to protect the system and hasten its recovery were developed.

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